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## NUMERICAL ANALYSIS OF NONLINEAR TRANSIENT SCATTERING OF LIGHT BY HYPERSOUND

Moscow KVANTOVAYA ELEKTRONIKA in Russian Vol 13, No 12, Dec 86 (manuscript received 5 Oct 85) pp 2447-2454

[Article by V. G. Manishin and G. A. Pasmanik, Institute of Applied Physics, USSR Academy of Sciences, Gorkiy]

[Abstract] Nonlinear transient stimulated Mandelshtam-Brillouin scattering of light by hypersound is analyzed theoretically by the method of numerical simulation. A layer of a nonlinear active medium in the path of two pairs of opposing light waves is considered, one pair of opposing waves with an anti-Stokes frequency shift between them, a hypersound wave being generated in the active medium by electrostrictive interaction of pairwise interfering light waves. Phased excitation of hypersound requires a frequency deviation of interacting waves from exact resonance, which is achieved here in the approximation of plane waves with slowly varying complex amplitudes. The system of five differential equations describing the propagation of four light waves and one hypersound wave through the active medium have been solved for appropriate boundary conditions corresponding to wavefront reversal dynamics in such hypersonic four-wave mirror, at the self-excitation threshold as well as at higher pumping intensity. The numerical solution has yielded the normalized intensity of an excited Stokes wave and of a reflected wave during absolute instability, also of the reflection coefficient, as functions of normalized to the hypersound relaxation time for various values of the system parameters. Mutual phasing of scattered waves is possible, typically with the aid of a nonreciprocal device such as a Faraday cell behind the nonlinear active medium. Numerical analysis of this situation has yielded the intensity gain as a function of the phase difference between waves on one side and, for the special case of waves in phase quadrature, stabilization of intensity across the nonlinear active medium. Figures 7; references 6: all Russian.

2415/12947  
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## DETERMINATION OF WEAK OPTICAL ABSORPTION OF OPTOACOUSTIC METHOD

Minsk ZHURNAL PRIKLADNOY SPEKTROSKOPII in Russian Vol 44, No 5, Nov 86  
(manuscript received 21 Jun 85) pp 824-828

[Article by S. A. Vinokurov]

[Abstract] The optoacoustic method of measuring optical absorption with the aid of microphones as detectors is analyzed for sensitivity, considering that pressure fluctuations in the optoacoustic chamber depend not only on the energy absorbed by a body inside but also on the geometry of the body and thermophysical properties of its material. For calculating the magnitude of an acoustic signal generated in the chamber and estimating the sensitivity, another significant parameter is introduced, namely the minimum recordable temperature fluctuations at the body surface. Further calculations are made with the aid of the equation of state for an ideal gas and the equation of a vibratory displacement transducer-membrane. The results indicate ways to optimize the chamber design and the microphone selection for use with a laser. An experimental apparatus has been built for design and performance evaluation, using an LTIPCh-7 laser with diaphragm and beam splitter as well as a reference chamber with an IMO-2N radiation power meter behind. Auxiliary components include a narrow-band amplifier, an amplifier-limiter, a summing amplifier, a synchronous amplifier, a V7-21 volt-meter, and a ChZ-32 frequency meter. The results of experiments with a pair of microphones and correspondingly two preamplifiers inside the chamber indicate that such an apparatus is most suitable for measuring weak optical absorption by the surface of transparent, light reflecting, or light diffusing bodies. The author thanks N.A. Pankratov for helpful discussion of the results. Figures 3; references 9: 6 Russian, 2 Western.

2415/12947  
CSO: 1862/80

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## MODE OF SOUND RADIATION DURING FORCED VIBRATIONS OF SHELLS IN COMPRESSIBLE FLUID

Moscow PRIKLADNAYA MATEMATIKA I MEKHANIKA in Russian Vol 50, No 5, Sep-Oct 86  
(manuscript received 19 Aug 85) pp 876-880

[Article by M. I. Guseyn-Zade, Moscow]

[Abstract] Radiation of sound from a vibrating sphere through a compressible fluid completely surrounding it is analyzed as a problem of forced vibrations, on the basis of the corresponding Helmholtz equation for the displacement potential. The solution to this equation describes the displacement potential as a series in spherical functions and yields the sound intensity in the fluid

as a polynomial function, with positive coefficients, of the inverse square of distance from the center of the sphere. The significance of lower-power terms increases while the effect of compressibility decreases with increasing distance from the sphere, in a manner which depends on the wave number and thus on the frequency. Figures 2; references 8: 6 Russian, 2 Western (both in Russian translation).

2415/12947

CSO: 1862/94

# PHOTOINDUCED CHANGE OF ACOUSTIC VELOCITY IN CENTRISYMMETRIC CRYSTALS IN EXTERNAL ELECTRIC FIELD

Leningrad PISMA V ZHURNAL TEKHNIЧЕСКОY FIZIKI in Russian Vol 12, No 18, 26 Sep 86 (manuscript received 26 Jun 86) pp 1134-1137

[Article by A. P. Zdebskiy, M. K. Sheynkman, A. N. Annaniyazov, and G. Garyagdyev, Institute of Semiconductors, UkSSR Academy of Sciences, Kiev]

[Abstract] A study of  $\text{SbSI}$ ,  $\text{SrTiO}_3$ ,  $\text{KTaO}_3$  single crystals with centrisymmetric lattice and ferroelectric properties was made, for the purpose of determining the effect of light on their electroacoustic characteristics such as dependence of the acoustic velocity in these crystals on the intensity of the external electric field. Longitudinal vibrations of bar specimens were induced in a longitudinal electric field consisting of a large constant component  $E_0$  and a small alternating one, with the  $\text{KTaO}_3$  bars at room temperature and at 77 K, with the  $\text{SrTiO}_3$  bars at room temperature, and with the  $\text{SbSI}$  bars in the paraelectric state at temperatures of 300-315 K. Measurements were made by the resonance-antiresonance method, in darkness and in white light of an incandescent lamp. The results have revealed that light causes the relative change of acoustic velocity  $\Delta v/v$  to be larger than proportional to  $\epsilon^3 E_0^2$  ( $\epsilon$  - dielectric permittivity of the material, probably owing to an increase of the defect concentration and because the induced polarization of light also depends here on the electric field intensity. This is indicated by the data describing the dependence of the photoacoustic effect on the electric field intensity and on the dielectric permittivity. Figures 2; references 11: 9 Russian, 2 Western.

2415/12947

CSO: 1862/35

PROPAGATION AND REFLECTION OF ONE-DIMENSIONAL ACOUSTIC PULSE IN DISCRETELY  
LAYERED LINEAR AFTEREFFECT MEDIUM

Tallinn IZVESTIYA AKADEMII NAUK ESTONSKOY SSR: FIZIKA MATEMATIKA in Russian  
Vol 35, No 3, Jul-Sep 86 (manuscript received 6 Dec 85) pp 271-278

[Article by A. Stulov, Institute of Cybernetics, ESSR Academy of Sciences]

[Abstract] An experiment for acoustic diagnostics of linear aftereffect media is designed which involves propagation of one-dimensional acoustic probing pulses and, in the case of discretely layered media, their reflection at interlayer boundaries. With the experiment correctly designed to include recording of pulse distortions each successive pulse is defined as a function of Lagrangian coordinates and time. The problem is then solved and the aftereffect parameters are calculated with the aid of a Laplace or Fourier integral transformation. The procedure is demonstrated first more generally on a medium consisting of two plane fluid layers, both homogeneous and one adjacent to a half-space, and then on the example of a viscoelastic layer with E-memory between two layers of ideal compressible fluid. Figures 1; references 7: 6 Russian, 1 Western.

2415/12947

CSO: 1862/33



UDC 621.373.5

RESEARCH IN PHYSICS OF NARROW-BAND SEMICONDUCTORS AND THEIR USE AS BASIS FOR TUNABLE INFRARED INJECTION LASERS

Moscow VESTNIK AKADEMII NAUK SSSR in Russian No 6, Jun 86

[Article by A. P. Shotov, doctor of physico-mathematical sciences]

[Abstract] Research in the physics of narrow-band (more precisely narrow-gap) semiconductor compounds of group IV and group VI elements, particularly PbS, PbSe, PbTe, SnS, SnSe, SnTe, PbSnSe alone or in solid solutions, is being conducted at the Institute of Physics (USSR Academy of Sciences) because of their suitability for infrared injection lasers. Their energy gap varies over the 0-0.3 eV range, depending on the composition and their laser emission wavelength can be varied over the 3-40  $\mu\text{m}$  range. Important factors are photo-electrical and optical characteristics of these materials, radiative recombination processes in them, and their energy spectra. Among lasers developed on this basis are continuous-wave and pulsed ones with a low threshold current density of 25 A/cm<sup>2</sup> at 10 K and 700 A/cm<sup>2</sup> at 80 K temperatures (A. P. Shotov, I. I. Zasavitskiy), also 46  $\mu\text{m}$  long-wave lasers (L. N. Kurbatov, A. D. Britov). A major application for these lasers are high-resolution spectrometers, developed jointly with the Institute of General Physics (USSR Academy of Sciences) for spectroscopy of molecules, chemical analysis of gases, identification of isotopes, etc. Other promising applications range from scientific ones such as tracking the effects of strong pulsed electric and magnetic fields on atoms and molecules to practical ones such industrial product inspection, atmospheric pollution control, and optical data processing. There is a need for developing semiconductor films capable of withstanding higher than room temperatures. This communication was discussed by V. G. Koloshnikov (Institute of Spectroscopy, USSR Academy of Sciences) and academicians L. N. Kurbatov, V. M. Tuchkevich, N. G. Basov, A. M. Prokhorov, N. M. Zhavoronkov, and A. P. Aleksandrov (president). Figures 7.

2415/12947

CSO: 2862/91

MODULATION AND CONVERSION OF LIGHT IN  $\text{LiNbO}_3$  CRYSTALS WITH REGULAR DOMAIN STRUCTURE

Moscow KVANTOVAYA ELEKTRONIKA in Russian Vol 13, No 12, Dec 86 (manuscript received 19 Mar 86) pp 2536-2538

[Article by A. A. Blistanov, A. A. Danilov, D. A. Rodionov, N. G. Sorokin, Yu. G. Turkov, and S. I. Chizhikov, Moscow Institute of Steel and Alloys]

[Abstract] Diffraction of light in a  $\text{LiNbO}_3$  crystal with regular domain structure was studied, such a structure having been attained by postgrowth thermoelectric treatment and a diffraction phase grating with a period equal to twice the domain wall thickness being formed upon application of an external electric field. Crystal specimens with a 2 mm X-dimension and a 5 mm Z-dimension were tested, in Z-polarized light of the  $\lambda = 0.63 \mu\text{m}$  wavelength and an electric field applied in the Z-direction. Calculations based on measurements, with the electrooptic coupling coefficient  $r_{33} = 0.9 \cdot 10^{-8}$  CGS units and the parameter  $Q = \lambda L / \Delta^2 n$  (L- depth of diffraction grating,  $\Delta$ - period of diffraction grating, n- diffraction order) characterizing the diffraction, have yielded the intensity-voltage characteristic in the maxima of diffraction orders 0, 1, 2 and the amplitude-frequency characteristic of such a multiple-domain crystal with piezoelectric resonances occurring at frequencies up to 1000 Hz, also the temperature dependence of second-harmonic generation characterized by a very narrow 44-47°C range with a peak at 45.4°C. For comparison, a crystal with a 40  $\mu\text{m}$  period of the domain structure is known to have a wider 38-54°C temperature range but no resonances above 100 Hz. Figures 3; references 9: 8 Russian, 1 Western.

2415/12947

CSO: 1862/82

 $\text{Tl}^0\text{V}_a^+$  COLOR CENTERS IN KC1-T1 CRYSTALS

Leningrad OPTIKA I SPEKTROSKOPIYA in Russian Vol 61, No 4, Oct 86 (manuscript received 13 Jan 86) pp 882-885

[Article by L. P. Smolskaya, B. D. Lobanov, N. T. Maksimova, and V. A. Grigorov]

[Abstract] A study of KC1-T1 crystals was made for the purpose of determining the mechanisms which cause their  $\text{Tl}^0\text{V}_a^+$  -centers to activate infrared laser emission at low temperature and prevent it at room temperature. Specimens of such crystals with various T1 concentrations were grown from vacuum-dried extra-pure KC1 salt by the Stokbarger method, whereupon color centers were generated in them by irradiation with a Co-60 source in doses up to  $10^4$  C/kg.

Most favorable for achieving a high concentration of  $Tl^{0+}V_a^{+}$ -centers was found to be doping a KCl crystal with 2 wt.%  $TlCl$ , exposure to  $\gamma$ -radiation at a temperature of 240-260 K, and subsequent illumination at that temperature simultaneously with F-light from a  $YAG:Nd^{3+}$  laser (second-harmonic radiation at 550 nm or 532 nm wavelength) and white light. Maximum luminescence of  $Tl^{0+}V_a^{+}$ -centers correspond to 1.5  $\mu m$  and 1.52  $\mu m$  wavelengths at 78 K and 300 K temperatures respectively, maxima in the excitation spectrum corresponding to 1.05  $\mu m$  and 1.08  $\mu m$  respectively, and the intensity decreasing to less than half as the temperature rises from 78 K to 300 K. This annihilation of  $Tl^{0+}V_a^{+}$ -centers by heating is hypothetically attributed to photothermal ionization, not from the lowest excited level associated with absorption of infrared light but rather in two stages from the excited level associated with absorption of F-light with transition of an electron to the first excited level by the first quantum of infrared laser radiation at 10.6  $\mu m$  wavelength and then to the excited level near the conduction band by the second quantum of that radiation. The data indicate and an experiment in the resonator cavity of  $YAG:Nd^{3+}$  laser confirm that KCl-Tl crystals with  $Tl^{0+}V_a^{+}$ -centers make excellent passive shutters for Q-switching, much more efficient at 300 K and much more stable at 78 K with a much wider infrared absorption band at 78-300 K than LiF crystals with  $F_2^{+}$ -centers. The authors thank L. M. Sobolev and V. M. Kostyukov for measuring excitation and luminescence spectra of crystals. Figures 1; references 12: 3 Russian, 9 Western.

2415/12947  
CSO: 1862/55

UDC 535.32

# MEASUREMENT OF REFRACTIVE INDEX OF GLASS BY METHOD OF THREE-BEAM INTERFEROMETRY AND TALBOT FRINGES

Leningrad OPTIKA I SPEKTROSKOPIYA in Russian Vol 61, No 4, Oct 86 (manuscript received 19 Mar 86) pp 713-715

[Article by Ye. Ye. Berezina and V. A. Levenberg]

[Abstract] A method of measuring the refractive index of new glasses is proposed which covers an unlimited range of absolute index values and infrared as well as visible light, applicable under extreme ambient conditions and requiring not more than the smallest sample to prepare specimens. The apparatus includes a modification of the Rayleigh three-beam interferometer, using a cylindrical lead-in lens and a wedge specimen with an angle smaller than  $1^\circ$ . The light beam from an LG-126 gas laser, after passage through an expanding lens, is split into three parallel ones by a diaphragm with three slits. The specimen is placed in the path of the center beam with its edge perpendicular to the center slit, and the interference pattern is observed through a microscope with a lens behind a stop. When the interference fringes

become too faint, especially during measurements in infrared light with use of an image converter, the three-slit diaphragm is replaced with a single-slit diaphragm which will produce Talbot interference fringes. Photoelectric recording is more accurate than photographic recording. The refractive index of K-14 glass in visible light ( $\lambda = 633$  nm) and in infrared light ( $\lambda = 1.1$   $\mu$ m) was measured with this apparatus, using a wedge specimen with an approximately  $0.5^\circ$  angle. Figures 3; references 5: all Russian.

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CSO: 1862/55

UDC 535.376

#### ELECTROLUMINESCENCE OF $\text{CdF}_2$ FILMS ACTIVATED BY RARE-EARTH ELEMENTS

Vilnius LITOVSKIY FIZICHESKIY SBORNIK in Russian Vol 26, No 6, Nov-Dec 86  
(manuscript received 6 Feb 86) pp 747-575

[Article by P. A. Pipinis, A. Yu. Kiveris, and A. K. Rimeyka, Vilnius State Pedagogical Institute]

[Abstract] Electroluminescence of  $\text{CdF}_2$  films containing and activated by ions of a rare-earth element is analyzed theoretically on the basis of an experimental study. In that study  $0.6 \pm 0.06$   $\mu$ m thick  $\text{CdF}_2$  films were produced from  $\text{CdF}_2$  powder by vacuum evaporation and deposition on glass substrates with conducting  $\text{SnO}_2$  layer at a temperature of 370 K. On such a film, subsequently doped with a rare-earth element ( $\text{Sm}^{3+}$ ,  $\text{Eu}^{3+}$ ,  $\text{Er}^{3+}$ ), was then deposited a 0.08  $\mu$ m thick  $\text{SiO}_2$  layer and on top of it an Al electrode. Application of an alternating voltage to these structures with different rare-earth elements induced luminescence with a line spectrum depending on the rare-earth element and with an intensity depending on the temperature, maximum at room temperature and much lower at 80 K. The frequency of the applied voltage was 5 or 10 kHz, luminescence measurements were made in a cryostat cooled by liquid nitrogen at a rate of 0.06 K/s. The temperature dependence of the luminescence intensity was found to be monotonic for  $\text{Er}^{3+}$ , nonmonotonic with several dips at various temperatures for  $\text{Sm}^{3+}$  and  $\text{Eu}^{3+}$ . These results are interpreted theoretically in terms of three possible mechanisms: 1) phonon-stimulated tunneling of electrons from surface levels to the conduction band, 2) Frenkel-Pool thermoelectric mechanism of radiation emission in an electric field, 3) above-barrier Schottky emission. The voltage dependence of the luminescence intensity, measured over the 25-80 V range with the luminescence intensity found to increase monotonically with increasing voltage, agrees only with the tunneling mechanism so that the latter is the likely one. With the Frenkel-Pool mechanism it agrees only in a weak electric field, below 80 kV/m, and not at all in a stronger one. The dominant process determining this voltage and temperature dependence of electroluminescence is generation of free electrons needed for impact excitation of luminescence centers in such films. Figures 6; tables 1; references 20: 6 Russian, 14 Western (1 in Russian translation).

2415/12947  
CSO: 1862/81

## EFFECT OF ULTRASONIC TREATMENT AND ANNEALING ON SUPERCONDUCTING TRANSITION TEMPERATURE OF STRAINED NIOBIUM

Leningrad FIZIKA TVERDOGO TELA in Russian Vol 28, No 11, Nov 86 (manuscript received 24 Apr 86) pp 3512/3514

[Article by L. A. Chirkina, O. I. Volchok, S. D. Lavrinenko, V. S. Okovit, and B. A. Khinkis, Kharkov Institute of Engineering Physics, UkSSR Academy of Sciences]

[Abstract] An experimental superconductivity study of niobium strained by twinning was made, for the purpose of determining the effect of subsequent ultrasonic treatment or thermal annealing on its superconducting transition temperature. Specimens of 99.89% pure polycrystalline Nb were annealed at 1700 K under a vacuum of  $8.5 \cdot 10^{-3}$  Pa for 8 h, to a 70-100  $\mu\text{m}$  grain size and a  $5 \cdot 10^9 \text{ cm}^{-2}$  dislocation density. They were then deformed by means of an impact pendulum, to produce 0.5  $\mu\text{m}$  thick twin-crystal interlayers 5-8  $\mu\text{m}$  apart with the total deformation not exceeding 2%. These specimens were subsequently heated to 300 K, the dislocation density having then reached  $2.2 \cdot 10^{10} \text{ cm}^{-2}$  in the accommodation zone as well as in the interlayers. The superconducting transition temperature was measured for ultrasonic treatment at 300 K and after annealing at 670 K respectively. The superconducting transition temperature, 9.22 K for Nb in the initial state, was raised to 9.26 K after twinning deformation and then dropped to 9.235 K as a result of ultrasonic treatment or thermal annealing, the difference being some additional blurring of the N  $\rightarrow$  S transition after ultrasonic treatment but not after thermal annealing. The authors thank I. A. Gindin for interest and helpful discussion. Figures 2; references 10: all Russian.

2415/12947

CSO: 1862/76

## FORMATION OF F-CENTERS AND SELF-LOCALIZED EXCITONS IN CsBr CRYSTAL UNDER ACTION OF PULSED ELECTRON BEAMS

Leningrad FIZIKA TVERDOGO TELA in Russian Vol 28, No 11, Nov 86 (manuscript received 10 Dec 85, in final version 30 May 86) pp 3473-3477

[Article by V. A. Kravchenko, V. M. Lisitsyn, and V. Yu. Yakovlev, Tomsk Polytechnic Institute imeni S. M. Korov]

[Abstract] An experimental study of CsBr crystals was made concerning primary color centers induced by electron bombardment. Electron beams with mean energy of 0.25 MeV and current density of 10 A/cm<sup>2</sup> were produced by an accelerator in pulses of 10 ns duration. Optical absorption and luminescence spectra were recorded over the 80-500 K temperature range, immediately after the end of a pulse, in a spectrometer with 7 ns and 40 ns resolution respectively over the 5.3-1.6 eV range and the 1.6-1.0 eV range of photon energy.

The absorption spectra were found to be essentially different in the two temperature ranges 80-160 K and 200-500 K. The spectra and the corresponding fairly exponential relaxation of optical density at 80 K and above indicate unstable absorption centers, dihaloidal self-localized excitons, induced at an efficiency which decreases with rising temperature. A measure of the efficiency is the initial maximum optical density, proportional to the power of excitation pulses within the 1-5 MW/cm<sup>2</sup> range. The optical density relaxes after a pulse, at a rate which increases with rising temperature. The kinetic characteristics of fundamental luminescence at the 3.5 eV level were found to be similar to those of optical absorption. The spectra at 295 K and above indicate primary formation of Frenkel defect pairs, pairing of F and H color centers, followed by secondary processes such as annihilation of those pairs and aggregation of H-centers into dimers with a (Br<sub>2</sub><sup>-</sup>)<sub>2</sub> structure. As the temperature rises, so does the probability that dissociation of such an FH quasi-molecule will be thermally activated, with the two components remaining in proximity to each other coupled in an FH<sub>nnn</sub> configuration. A comparison with data on NaCl crystals indicates that this formation of radiative defects is evidently not influenced by the structure of the crystal lattice, the crystal lattice of CsBr being a b.c.c. one. Figures 5; references 9: 5 Russian, 4 Western.

2415/12947  
CSO: 1862/76

UDC 535.592.539.144.4

#### OPTICALLY INDUCED NUCLEAR MAGNETIC RESONANCE IN SEMICONDUCTORS

Leningrad FIZIKA TVERDOGO TELA in Russian Vol 28, No 11, Nov 86 (manuscript received 28 May 86) pp 3462-3465

[Article by V. K. Kalevich, Institute of Engineering Physics imeni A. F. Ioffe, USSR Academy of Sciences, Leningrad]

[Abstract] Nuclear magnetic resonance was observed for the first time in GaAs semiconductors upon heating of the cold reservoir in the nuclear spin system by an oscillating field of electrons in a strong alternating magnetic field. Theoretical analysis indicates that a radio-frequency field of electrons is attainable by modulation of the stimulating light. This is confirmed by experimental data on p-GaAs <Ge> and p-Al<sub>0.26</sub>Ga<sub>0.74</sub>As<Zn> crystals, including their NMR spectra and luminescence depolarization curves. The stimulating light, (either its intensity or its degree of circular polarization,) was modulated by means of a KDP crystal at the NMR frequency. The authors thank B. P. Zakharchenya for interest, V. G. Fleysher and I. A. Merkulov for discussions, and V. L. Korenev for assistance in the experiment. Figures 2; references 14: 11 Russian, 3 Western (1 in Russian translation).

2415/12947  
CSO: 1862/76

IDENTIFICATION OF NEW CRYSTALLINE PHASE OF  $\text{NH}_4\text{HSeO}_4$ 

Leningrad FIZIKA TVERDOGO TELA in Russian Vol 28, No 11, Nov 86 (manuscript received 25 Apr 86) pp 3368-3373

[Article by A. A. Sukhovskiy, Yu. N. Moskvich, O. V. Rozanov, and I. P. Aleksandrova Institute of Physics imeni L. V. Kirenskiy, Siberian Department, USSR Academy of Sciences, Krasnoyarsk]

[Abstract] A new crystalline phase of  $\text{NH}_4\text{HSeO}_4$  in addition to the five known

superionic (I)  $\xrightarrow{T_{s1} = 401 \text{ K}}$  paraelectric (II)  $\xrightarrow{T_i = 260 \text{ K}}$  disproportionate (III)  
 $\xrightarrow{T_{f1} = 252 \text{ K}}$  ferroelectric (IV)  $\xrightarrow{T_{f2} = 98 \text{ K}}$  low-temperature (V) phases had been

identified at some temperature within the 252-271 K range, both phases II and III having been found to be unstable. Measurements made mostly at 256 K by the NMR method using  $^{77}\text{Se}$  ( $^2\text{D}$  for crystals with D replacing up to 80% of H) revealed changes of dielectric and optical characteristics occurring slowly, within 1-2 h. For a subsequent study of this new phase VI, crystals were grown and maintained at 259 K. From the crystal of monoclinic phase II at room temperature were cut three cylindrical specimens parallel respectively to the three principal axes of the pseudorhombic phase II. Cooling to 257 K restored the new phase VI. Spectroscopy by the NMR method using  $^{77}\text{Se}$ , with rotation about those three axes, revealed four tensors of magnetic shielding of  $^{77}\text{Se}$  nuclei. Structural examination by the x-ray diffraction method revealed a structure of this phase identical to the rhombic structure of  $\text{NH}_4(\text{H,D})\text{SeO}_4$  at 300-305 K. The monoclinic-to-rhombic phase transition was found to occur as a result of nucleation and nondirectional growth of phase VI single crystals in the phase II matrix, the stability limit of the monoclinic phase II depending on the % D content. The authors thank A. A. Chernov for discussion. Figures 4; tables 3; references 15: 6 Russian, 9 Western.

2415/12947

CSO: 1862/76

UDC 539.2

## THEORY OF RECOMBINATIONALLY STIMULATED ATOM JUMPS IN NONMETALLIC CRYSTALS

Leningrad FIZIKA TVERDOGO TELA in Russian Vol 28, No 11, Nov 86 (manuscript received 19 Nov 85, in final version 13 May 86) pp 3389-3395

[Article by V. L. Vinetskiy and G. Ye. Chayka, Institute of Physics, UkSSR Academy of Sciences, Kiev]

[Abstract] Mechanisms of atom jumps in nonmetallic crystals from one equilibrium state to a neighboring one upon capture of a free electron are

analyzed, the nonadiabatic motion of electrons rendering the concept of thermal fluctuations and thus a purely statistical process irrelevant here. Instead, an atom jump with attendant lowering of the activation energy is shown to occur preferentially from levels of high-energy electron states with attendant energy dissipation rather than from the bottom of the conduction band. Considering that the electron distribution in the high-energy range is influenced by illumination, differences between atom jumps under light and in darkness respectively are evaluated for a refinement of this theory. First the probability of recombinationally stimulated jumps of atoms with multiphonon transitions during dark diffusion is calculated, assuming a Boltzmann distribution. Next the probability of recombinationally stimulated jumps of atoms during photoionization is calculated and found to be very much higher. Tables 1; references 20: 12 Russian, 8 Western (1 in Russian translation).

2415/12947  
CSO: 1862/76

#### EXCITONS BOUND TO IMPURITY PHOSPHORUS AND ARSENIC ATOMS IN SILICON

Moscow ZHURNAL EKSPERIMENTALNOY I TEORETICHESKOY FIZIKI in Russian Vol 91, No 3(9), Sep 86 (manuscript received 14 Mar 86) pp 1093-1104

[Article by M. V. Gorbunov and A. S. Kaminskiy, Institute of Radio Engineering and Electronics, USSR Academy of Sciences]

[Abstract] An experimental study of recombinatorial radiation in Si doped with P or As was made, with the impurity concentration sufficiently low to leave many isolated donors and donor pairs capable of capturing free excitons. Specimens of Si single crystals were grown by the Czochralski method or by the floating-zone method. Square bars  $2 \times 2 \text{ mm}^2$  in cross-section and 20 mm long were cut out along each of the crystallographic axes [111], [001], [112] for spectral analysis without and under uniaxial compressive strain. For recording the spectra at temperatures of 2-4.2 K and 6-35 K, the specimens were cooled with liquid helium and with gaseous helium respectively. Excitation was supplied by an LG-106M-1 Ar-laser having a power of 0.5 W. Emission was recorded with an FEU-62 photomultiplier operating as photon counter and was analyzed with an SDL-1 fast spectrometer or, for higher resolution, an IT-28-30 fast interferometer in which the standard mirrors had been replaced with multilayer coatings for maximum reflection at the  $\lambda = 1.08 \text{ }\mu\text{m}$  wavelength. The patterns of the radiation spectra with their characteristic bands are interpreted by associating them with processes occurring within the exciton-impurity zone such as exciton jumping  $\text{ED} + \text{D}_2 \rightarrow \text{D} + \text{ED}_2$ , with attendant energy transfer dependent on and thus controllable by uniaxial deformation. The authors thank Ya. Ye. Pokrovskiy for collaboration and valuable suggestions concerning the results, also A. B. Lopatin for programming computer-aided processing of experimental data. Figures 8; references 21: 11 Russian, 10 Western (1 in Russian translation).

2415/12947  
CSO: 1862/34



DEPENDENCE OF PARAMETERS OF HIGH-RESISTIVITY GaAs LAYERS PRODUCED BY  
BOMBARDMENT WITH  $\text{Ar}^+$  IONS ON ORIENTATION OF CRYSTAL AND ON CONCENTRATION OF  
FREE CHARGE CARRIERS

Leningrad FIZIKA I TEKHNICA POLUPROVODNIKOV in Russian Vol 20, No 9, Sep 86  
(manuscript received 8 Jan 86, signed to press 17 Mar 86) pp 1724-1726

[Article by P. V. Pavlov, V. M. Kogan, S. A. Khakimova, and N. N. Abramova,  
Gorkiy Institute of Engineering Physics, Gorkiy State University imeni  
N. I. Lobachevskiy]

[Abstract] An experimental study of high-resistivity n-GaAs layers produced by bombardment with heavy ( $\text{Ar}^+$ ) ions was made, for the purpose of determining the dependence of their thickness and electrical resistance on the orientation of the substrate crystal relative to the ion beam and on the concentration of free charge carriers in it. Targets were bombarded with doses of 40 keV  $\text{Ar}^+$ -ions not reaching the amorphization threshold. Electrical measurements were made with the layers in a diode configuration, an Al-electrode having been deposited on the surface which had been bombarded and an Au+Ge contact tab fused onto the back surface at a temperature of 673 K. The electrical resistance was measured over the linear range of the current-voltage characteristic with the voltage not exceeding 20 mV. The capacitance-voltage characteristic was measured for calculation of the layer thickness, taking into account the space-charge region. The results indicate that the layer thickness builds up with increasing ion dose to saturation under a dose of  $10^{13} - 10^{14} \text{ cm}^{-2}$ , whereupon it remains almost constant with the final thickness depending on the concentration of free charge carriers and becoming smaller as the latter increases, while the electrical resistance first increases from an initial level to a maximum and then drops to zero with the maximum decreasing and requiring larger ion doses as the concentration of free charge carriers increases. Under small ion doses (below  $2 \cdot 10^{11} \text{ cm}^{-2}$ ) a thicker layer with higher electrical resistance builds up on a substrate crystal not oriented with its channeling  $\langle 110 \rangle$  axis in the direction of the ion beam, evidently owing to the higher defect mobility and the lower probability of ion entrapment in this case. Under large ion doses (above  $10^{12} \text{ cm}^{-2}$ ) the layer thickness depends on the defect mobility during bombardment or stimulated diffusion, but the mobility of compensating defects does not depend on the crystal orientation relative to the ion beam. These trends differ from those which characterize n-GaAs layers produced by bombardment with  $\text{Zn}^+$ -ions. Figures 2; references 4: 2 Russian, 2 Western.

2415/12947  
CSO: 1862/93

# ENTRAPMENT OF IMPURITY COMPLEXES DURING EPITAXIAL GROWTH OF GaAs FROM GASEOUS PHASE

Leningrad FIZIKA I TEKHNIKA POLUPROVODNIKOV in Russian Vol 20, No 9, Sep 86  
(manuscript received 28 Dec 85, signed to press 18 Feb 86) pp 1701-1703

[Article by I. A. Bobrovnikova, L. G. Lavrentyeva, and S. Ye. Toropov,  
Siberian Institute of Engineering Physics imeni V. D. Kuznetsov, Tomsk State  
University, Tomsk]

[Abstract] An experimental study of epitaxially growing GaAs doped with Te was made, for the purpose of monitoring the entrapment of doping complexes and its dependence on the substrate orientation as well as on the process conditions. Semiconductor layers were deposited from the gaseous phase,  $\text{AsCl}_3 + \text{H}_2$ , with the source temperature  $830^\circ\text{C}$  and the substrate temperature  $750^\circ\text{C}$ . The  $\text{AsCl}_3$  pressure was varied stepwise over the 11-800 Pa range, causing the electron concentration in GaAs layers to vary correspondingly from  $10^{18} \text{ cm}^{-3}$  to  $1.5 \cdot 10^{19} \text{ cm}^{-3}$ . The source contained Te in a concentration of  $N_{\text{Te}} = 4 \cdot 10^{18} \text{ cm}^{-3}$ , GaAs layers with (111)A, (001), (110) orientations as well as with orientations deviating from each of these by  $2^\circ, 4^\circ, 6^\circ, 8^\circ$  were used as substrates. Photoluminescence of epitaxially grown layers was excited with an LG-75 laser ( $\lambda = 0.638 \mu\text{m}$  wavelength) and its spectra were recorded with a Ge-photoresistive detector. These spectra were then analyzed by the Alentsev method, with the aid of a computer. The results indicate entrapment of impurity complexes during crystallization rather than during postcrystallization annealing and at a rate depending on the structure of the growth surface, a (100) face being most favorable and a (111)A face being least favorable for formation of the  $[\text{V}_{\text{Ga}} - \text{Te}_{\text{As}}]$  complex. Figures 2; references 5: 4 Russian, 1 Western.

2415/12947  
CSO: 1862/93

UDC 534.18:537.84

SOME THERMODYNAMIC PROPERTIES OF MAGNETIC FLUID UNDER HIGH PRESSURE

Dushanbe DOKLADY AKADEMII NAUK TADZHIKSKOY SSR in Russian Vol 29, No 4, Apr 86  
(manuscript received 2 Dec 85) pp 212-214

[Article by V. F. Nozdrev and B. Kh. Khamzayev, Tadzhik State University imeni V. I. Lenin]

[Abstract] Thermodynamic properties of a magnetic fluid under pressures up to 100 MPa were measured at a constant temperature of 293 K. The experimental fluid was a kerosene carrier with a 20% volume fraction of magnetite particles, under atmospheric pressure, stabilized with oleic acid. Analogous measurements were made on pure kerosene, for comparison and because such data have been missing. The density of both was found to increase nonlinearly with rising pressure, along with increasing volume fraction of a fixed mass fraction of magnetic particles. The difference between velocity of ultrasound in pure kerosene and in the magnetic fluid was also found to increase with rising external pressure. The adiabatic compressibility was found to decrease with rising external pressure, owing to increasing inertia of a fluid containing a solid fraction with a density much higher than that of the carrier substance. These measurements were supplemented with measurement of constant-volume and constant-pressure specific heats by the ultrasonic method, the calorimetric method not being practicable under high pressures, so that their ratio could be determined and correlated with the trend of adiabatic compressibility. Figures 1; tables 2; references 3: all Russian.

2415/12947

CSO: 1862/87

SYSTEM OF EQUATIONS FOR BOUNDARY LAYER OF DILATANT FLUIDS

Moscow USPEKHI MATEMATICHESKIKH NAUK in Russian Vol 41, No 5, Sep-Oct 86  
(manuscript received 10 Apr 85) pp 195-196

[Article by V. N. Samokhin, Moscow Institute of Polygraphy]

[Abstract] The system of differential equations describing steady plane-parallel symmetric flow in the boundary layer of a dilatant fluid, in terms

of velocity components  $u(x,y)$ ,  $v(x,y)$  in the complex plane, is reduced to a single nonlinear differential equation upon introduction of two new independent variables  $x = x$ ,  $\phi = \phi(x,y)$  and a new sought function  $w(x,\phi) = u^2$ . Two theorems are stated and proved concerning existence of a generalized solution to that equation and then a solution satisfying almost everywhere the original system of equations, these solutions also being unique. Unlike for a pseudoplastic fluid and a Newton-Prandtl fluid, in this case  $u=U(x)$  at finite  $y$ . The author thanks O. A. Oleynik for interest. References 5: all Russian.

2415/12947  
CSO: 1862/96

UDC 539.3:534.1

# QUASI-RESONANCES IN PROBLEM OF FORCED VIBRATIONS FOR THIN ELASTIC SHELL INTERACTING WITH FLUID

Moscow FUNKTSIONALNYY ANALIZ I EGO PRILOZHENIYA in Russian Vol 20, No 4, Oct-Dec 86 (manuscript received 25 May 86) pp 17-28

[Article by D. G. Vasilyev and V. B. Lidskiy, Institute of Problems in Mechanics, USSR Academy of Sciences]

[Abstract] Forced three-dimensional vibrations of a closed thin elastic shell filled with nonviscous compressible fluid is described by a system of four linear equations in operator form, with the shell thickness as small parameter and with Young's modulus of the shell material defined as a complex quantity  $E = E_0(1 + i\gamma)$  to account for internal friction characterized by the small positive  $\gamma$ . The problem is simplified by extraction of the transient component and by assumptions according to V. Z. Vlasov:  $n_{pq} = 0$  and  $p+q \leq 6$ , coordinates  $p = 1, 2, 3$  and  $q = 1, 2, 3$ . A theorem validating asymptotic expansion in powers of the relative shell thickness is proved with the aid of two lemmas, whereupon the problem is referenced to the corresponding Dirichlet eigenvalue problem. After asymptotic expansions have been obtained for frequencies generally not equal to the Dirichlet eigenvalue and in a special case equal to it, quasi-resonances are sought within the  $0 < [\omega_{\min}, \omega_{\max}]$  frequency range. The necessary and sufficient condition for a quasi-resonance within this range is established by proof of the existence theorem, this condition being that at least one natural frequency of the shell or at least one eigenvalue of the corresponding Dirichlet problem lie within that frequency range. Figures 1; references 8: 6 Russian, 2 Western (1 in Russian translation).

2415/12947  
CSO: 1862/95

UDC 621.373.826.038.823

FORMATION OF SHORT GIANT RADIATION PULSE IN YAG:Nd<sup>3+</sup> LASER WITH UNSTABLE RESONATOR

Moscow KVANTOVAYA ELEKTRONIKA in Russian Vol 13, No 12, Dec 86 (manuscript received 4 Apr 86) pp 2541-2542

[Article by Yu. L. Kokurin, N. Ye. Kuzmenko, V. M. Mizin, R. A. Petrenko, A. A. Statsenko, A. N. Sukhanovskiy, and N. Ya. Nedbayev, Institute of Physics imeni P. N. Lebedev, USSR Academy of Sciences, Moscow]

[Abstract] Formation of short giant radiation pulses in a YAG:Nd<sup>3+</sup>-laser was studied in an experiment with Q-switching by means of a bleachable nickel dye in an organic solvent having a relaxation time of 1 ns. The laser crystal, between this shutter and a diaphragm with a hole 3 mm in diameter, was placed in a 200 mm long resonator cavity formed by two plane mirrors with a 100% and 15% reflection coefficient respectively. An identical crystal was used in a telescopic amplifier between two spherical mirrors with a 100% reflection coefficient each, a concave one reflecting into it the laser radiation and a convex one at the other end. Both crystals were 8 mm in diameter and 80 mm long. Laser and amplifier were optically decoupled by means of another shutter, with a 1% initial transmission coefficient, placed between the resonator exit mirror and the amplifier receiving mirror. The results of this experiment confirm the effectiveness of an unstable resonator as universal means of optimizing all laser pulse-beam energy and time characteristics, pulses of 50 mJ energy and 2.5 ns duration in a beam with not more than 3' divergence and amplified to 400 mJ at a density of inverse population 4 times higher than the threshold for emission. Figures 2; references 9: 6 Russian, 3 Western (1 in Russian translation).

2415/12947  
CSO: 1862/82

KINEMATIC MODE LOCKING IN CONTINUOUS-WAVE YAG:Nd<sup>3+</sup> RING LASER

Moscow KVANTOVAYA ELEKTRONIKA in Russian Vol 13, No 12, Dec 86 (manuscript received 16 Oct 85) pp 2479-2485

[Article by L. S. Kornishenko, T. V. Klykova, N. V. Kvartsov, V. A. Sidorov, A. M. Susov, and Yu. P. Yatsenko, Scientific Research Institute of Nuclear Physics, Moscow State University imeni M. V. Lomonosov]

[Abstract] A study of kinematic mode locking in a solid-state ring laser was made, specifically in a YAG:Nd<sup>3+</sup> laser with variable resonator configuration. A crystal and an iris, the laser crystal 90 mm long and 5 mm in diameter, were placed between two spherical mirrors with either 50 cm or 100 cm radii of curvature and a 99% reflection coefficient each. The resonator cavity was completed by two plane mirrors with a device for oscillating either one or both mirrors at a frequency of 250 Hz to a 250  $\mu$ m deflection amplitude and thus periodically varying the cavity perimeter. Both bidirectional and unidirectional circulation was considered, with a 50 MHz acoustooptic traveling-wave modulator or a Faraday cell used for suppressing one of the waves in the latter case. The conditions of the experiment were quantitatively simulated for a correlation of measurements with theoretical analysis. The results, in close agreement, indicate concurrence of opposing waves at an oscillating mirror even when the coupling is weak, at a location which changes as the coupling coefficient is varied by means of an adjustable plate. When the opposing waves have the same frequency after having been reflected and backscattered by an oscillating mirror, then their frequencies at all other resonator surfaces will differ and the difference will generally be larger than the locking bandwidth. When their frequencies are equal at any stationary resonator surface, then their frequencies will also be equal upon reflection and backscattering by at least one other resonator surface. In the experiment such another surface was the nearest to that stationary one surface of the active medium. On this basis has been established the threshold coupling for stable mode locking, and oscillation of only one mirror found to be most favorable. Figures 6; references 16: 12 Russian, 4 Western.

2415/12947  
CSO: 1862/82

## PARAELECTRODE EFFECTS IN PERIODIC-PULSE EXCIMER LASER

Moscow KVANTOVAYA ELEKTRONIKA in Russian Vol 13, No 12, Dec 86 (manuscript received 16 Sep 85) pp 2403-2407

[Article by R. V. Arutyunyan, V. M. Borisov, A. Yu. Vinokhodov, Yu. B. Kiryukhin, and A. N. Morozov, Institute of Atomic Energy imeni I. V. Kurchatov, Moscow]

[Abstract] An experimental study of a periodically pulsed XeCl-laser ( $\lambda = 308$  nm wavelength) was made, for the purpose of determining the dependence of discharge compression on the electrode material. Laser pulses of 0.5 J energy and 50 ns width at half-amplitude were focused on the cathode within a  $1 \text{ mm}^2$  large spot through a lens with an  $f = 30$  cm focal length. The cathode was a disk made of duralumin carrying six pellets 1 cm in diameter of a different material each (Al, Fe, stainless, Cu, W, Zn) and uniformly spaced around a circle so that each alone could in turn be placed under the laser beam by rotation of the disk without the need to open and reclose the discharge chamber. Discharge in the  $100 \text{ cm}^3$  large chamber with helium under a pressure of 1.2 atm was produced, upon preionization by ultraviolet light, between this cathode and a reticular anode made of stainless steel with a  $T = 0.5$  transmission coefficient. The time lag of the discharge pulse behind the incident laser pulse was measured and found to increase with increasing energy of the laser pulse in helium. These measurements as well as photographs of full-volume and compressed discharges have revealed that materials requiring most heat for vaporization are most suitable for the cathode, considering that compression of the discharge is caused by hot spots on the cathode surface with attendant formation of metal vapor as well as by acoustic vibrations with attendant fluctuations of the gas density resulting in local inhomogeneities. The conclusion has been confirmed by subsequent experiments with a  $\text{HCl}:\text{Xe}:\text{He} = 1:10:1000$  lasing gas mixture and separate electric-discharge pumping of two identical laser modules, one cathode made of pure stainless steel and the other cathode made of stainless steel coated with a 0.3 mm thick tantalum foil. Tantalum having a very latent heat of evaporation, the laser with the Ta-coated cathode in the discharge chamber performed much better at pulse repetition rates above 400 Hz. The authors thank I. Ya. Smirnov for assistance in preparing and assembling the experimental equipment. Figures 5; references 6: 5 Russian, 1 Western.

2415/12947

CSO: 1862/82

## HIGH-POWER LASER SET WITH PLATE-SHAPED AMPLIFIER ON NEODYMIUM GLASS GENERATING PICOSECOND PULSES AT REPETITION RATES UP TO 1 Hz

Moscow KVANTOVAYA ELEKTRONIKA in Russian Vol 13, No 12, Dec 86 (manuscript received 10 Sep 85) pp 2391-2395

[Article by A. Varanavichyus, R. Grigonis, R. Danelyus, A. Piskarskas, and D. Podenas, Vilnius State University imeni V. Kapsukas]

[Abstract] A high-power multistage laser set with neodymium-phosphate glass as active medium and with optical pumping of all stages has been designed, built, and tested. The oscillator stage with a glass rod (2.0 wt.% Nd) 5 mm in diameter and 100 mm long in an elliptical luminaire and with an extractor of single pulses behind is followed by four amplifier stages: 1) glass rod (2.9 wt.% Nd) 5 mm in diameter and 100 mm long in an elliptical luminaire, 2) glass rod (2.9 wt.% Nd) 6 mm in diameter and 110 mm long in an elliptical luminaire, 3) glass rod (2.0 wt.% Nd) 7 mm in diameter and 140 mm long in a cylindrical luminaire, 4) glass plate (2.0 wt.% Nd) 5 mm thick and 28x140 mm<sup>2</sup> large between diffusely reflecting plates of MgO ceramic. The advantages of a plate over a cylinder with equal cross-sectional area in the last amplifier stage are a much higher cooling rate and a negligible depolarization of linearly polarized light, except at the edges. The amplifier is followed by a 15 mm long KDP of crystal acting as second-harmonic generator, with up to 40% conversion efficiency, and then a pair of 4 cm long KDP crystals with e-oe interaction as parametric generator in the output stage. With its design optimized, this laser set has the capability to generate pulses of up to 40 mJ energy and approximately 3 ps duration at a repetition rate of 1 Hz. Figures 3; tables 1; references 20: 8 Russian, 12 Western.

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## MOLECULAR PHOTODISSOCIATION LASER EMITTING BLUISH-GREEN LIGHT WITH ENERGY OF 3 J

Leningrad PISMA V ZHURNAL TEKHNIЧЕСКОY FIZIKI in Russian Vol 12, No 23, 12 Dec 86 (manuscript received 21 Aug 86) pp 1423-1429

[Article by S. L. Bazhulin, N. G. Basov, S. N. Burgimov, V. S. Zuyev, A. S. Kamrukov, N. P. Kozlov, A. G. Opekan, and Yu. S. Protasov]

[Abstract] A photodissociation laser emitting in the 480+30 nm wavelength band has been produced with HgBr<sub>2</sub> vapor, by effective depletion of the lower (X) level after widened B—X ionic-covalent transition through vibrational relaxation upon collisions of active HgBr<sub>2</sub> molecules against atoms and molecules of the buffer gas. The advantages of HgBr<sub>2</sub> over other media lasing bluish-green are larger cross-sections for induced transitions and regenerability of active molecules so that high gain and periodically-pulsed operation at a high repetition rate in a closed cycle become realizable. The experiment



was performed with wideband optical rather than conventional electric-discharge pumping, with the 110 cm long laser chamber heated to 250°C and the optical pump inside the chamber distributed over the middle 50 cm. The optical pump was a linearly stabilized glow discharge at the dielectric surface, the laser being periodically pulsed at repetition rates of 0.1-100 Hz with an energy varied over the 0.95-2.85 kJ range by artificial stimulation of breakdown wave processes in an Ar + N<sub>2</sub> mixture with the aid of 3-9 μF capacitors discharging from 25 kV. Optimum were found to be an Ar:N<sub>2</sub> = 1:1.5 mixture under a total pressure of 2.5 atm and an electron concentration of (0.8-2) · 10<sup>17</sup> cm<sup>-3</sup> in the HgBr<sub>2</sub> vapor. As buffer gas were used SF<sub>6</sub>, CF<sub>4</sub>, N<sub>2</sub>, or their mixtures with inert gases under a total pressure of 0.7-3 atm. Emission of pulses with an energy of 3 J by this HgBr-laser was achieved at an overall efficiency of 0.27%, cutoff being caused by a drop of the photoexcitation rate below the threshold upon photodissociation of HgBr<sub>2</sub> molecules and by a drop of the pumping luminous flux density with increasing distance from the discharge surface. Consequently, the emission energy was found to have saturated at the 3 J level, even with the pumping energy increased from 0.95 kJ to 2.85 kJ. The authors thank Yu. Yu. Stoylov for helpful discussions and V. V. Pochtarev for assistance. Figures 2; references 11: 7 Russian, 4 Western.

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UDC 621.373:535

# EFFECT OF COHERENT PROCESSES ON LIGHT PULSES IN Ar<sup>+</sup>-LASER WITH ACTIVE MODE LOCKING

Leningrad OPTIKA I SPEKTROSKOPIYA in Russian Vol 61, No 4, Oct 86 (manuscript received 9 Apr 86) pp 898-900

[Article by A.A. Apolonskiy]

[Abstract] A study of the Ar<sup>+</sup>-laser (λ = 488 nm wavelength) with active mode locking was made, involving radiation spectrum and pulseform analysis, for the purpose of scrutinizing the role of coherent processes. The inside channel of the discharge tube containing the active medium was formed by tungsten disks 3 mm in diameter, with the argon pressure varied over the 0.2-0.4 torr range at a discharge current of 30 A. The mean light intensity in the resonator cavity did not exceed 50 W/cm<sup>2</sup> and the phase relaxation time T<sub>2</sub> remained within the 100-150 ps range, according to measurements at the ion temperature. The pulseform was recorded and the pulse duration was measured with an Agat-SFZ apparatus. The product of maximum attainable pulse duration τ = 50 ns and width of the frequency spectrum D = 9 GHz corresponded quantitatively (τD = 0.45) to a Gaussian pulseform. Oscillations along the pulse "tails", observed when D > T<sub>2</sub><sup>-1</sup>, are attributable to coherent interaction of light and the active medium. An increase of the pulse propagation velocity in the active medium, observed when τ < T<sub>2</sub>, is attributable to coherent amplification. Both effects are limited by finiteness of the phase relaxation time and by radial nonuniformity of the radiation field. The author thanks S.A. Babin, A.A. Zabolotskiy,

K. P. Komarov, and V. P. Safonov for helpful discussion. Figures 2; references 13: 8 Russian, 5 Western ( 1 in Russian translation).

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CSO: 1862/55

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#### SELF-ACTION IN PULSED CO<sub>2</sub>-LASER AS SOURCE OF RADIATION WAVEFRONT INSTABILITY

Leningrad OPTIKA I SPEKTROSKOPIYA in Russian Vol 61, No 4, Oct 86 (manuscript received 9 Apr 86) pp 895-898

[Article by S. V. Fedorov and M. S. Yuryev]

[Abstract] Scattering of laser radiation by compression waves forming in the gaseous medium of a CO<sub>2</sub>-laser, owing to dependence of the heating rate on the radiation intensity, is analyzed with an intensity-dependent and therefore oscillating heat component added to the constant pumping heat. Only small-scale nonhomogeneity of the laser medium needs to be considered and, to account for interaction of acoustic waves and laser radiation, a parabolic equation describing the distorted electromagnetic field supplements the wave equation describing an adiabatic compression wave in the acoustic approximation. The instability length representing the increment in space is calculated as a function of time, taking into account the amplification of laser radiation and also the decay integral. The increment in time is calculated and the dispersion equation is obtained for a thin layer of the laser medium with "frozen" ambient medium, in which case the normal field gradient and the amplitude amplification can be disregarded. Figures 2; references 5: 4 Russian, 1 Western.

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CSO: 1862/55

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#### OPTICALLY PUMPED LiF-LASER CRYSTAL WITH STABLE F<sub>2</sub><sup>+</sup> COLOR CENTERS

Moscow KVANTOVAYA ELEKTRONIKA in Russian Vol 13, No 11, Nov 86 (manuscript received 17 Feb 86) pp 2328-2330

[Article by N. A. Ivanov, Ye. D. Isyanova, F. V. Karpushko, B. D. Lobanov, N. T. Maksimova, A. M. Provorov, N. A. Saskevich, G. V. Sinitsyn, V. M. Khulugurov, A. G. Shneyder, and A. S. Yasyukevich, Institute of Physics, BSSR Academy of Sciences, Minsk]

[Abstract] The first laser employing LiF crystals with stable F<sub>2</sub><sup>+</sup>-centers by optical pumping was activated. Two groups of crystals were used in the experiment, differing in size and shape (3x5x76 mm<sup>3</sup>, 7x8x24 mm<sup>3</sup>), coloration

having been produced radiatively by a different technology in each case. The crystals were pumped by six INP2-7/120 flashlamps with an energy up to 1.5 kJ in flashes of approximately 60  $\mu$ s duration, through light filters absorbing all short-wave radiation outside the absorption band of  $F_2^+$ -centers so as to prevent photoconversion of these centers and also diminish heating of the crystal. The laser operates at room temperature, with forced air-cooling of the crystal. The resonator is formed by opaque spherical mirrors with an  $R > 0.99$  reflection coefficient for 0.89-0.102  $\mu$ m wavelengths. An aluminum replica of a diffraction grating with 600 lines/mm in an autocollimating configurations is used for tuning the radiation wavelength, in a 48 cm long either dispersive or nondispersive resonator. With a nondispersive resonator, emission pluses of 12  $\mu$ s duration with an energy of 4-8 mJ were recorded at pumping levels above the approximately 80 J threshold. The radiation was found to be tunable over the 0.89-1.03  $\mu$ m wavelength range or the 0.9-0.99  $\mu$ m wavelength range, depending on the kind of crystal, with the emission line not wider than 3 nm and with maximum energy emitted at  $\lambda = 0.94 \mu$ m or  $\lambda = 0.96 \mu$ m wavelength respectively. Radiation emitted by both kinds of crystals in a nondispersive resonator is linearly polarized at pumping energy levels not higher than 10% above the threshold, but the degree of this polarization drops sharply and stabilizes at 6-10% as the pumping energy level is raised. Figures 3; references 13: 10 Russian, 3 Western.

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CSO: 1862/77

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# RECORDING SUBPICOSECOND HIGH-POWER PULSES OF CONTINUOUSLY-TUNABLE RADIATION EMITTED BY $LiF:F_2^-$ LASER

Moscow KVANTOVAYA ELEKTRONIKA in Russian Vol 13, No 11, Nov 86 (manuscript received 29 Aug 85) pp 2262-2266

[Article by A. V. Babushkin, T. T. Basiyev, N. S. Vorobyev, S. V. Mirov, A. M. Prokhorov, Yu. N. Serdyuchenko, and M. Ya. Shchelev, Institute of General Physics, USSR Academy of Sciences, Moscow]

[Abstract] Emission of ultrashort high-power radiation pulses by a  $LiF:F_2^-$  laser was recorded in an EOK-3Ye electron-optical chamber operating with a linear sweep, the LiF crystal with  $F_2^-$  color centers being pumped by a glass(GLS1):Nd laser ( $\lambda = 1.06 \mu$ m wavelength) with simultaneous Q-switching and passive mode locking. A 3282 dye solution in nitrobenzene was used as nonlinear absorber for Q-switching and passive mode locking. Picosecond and subpicosecond pulses of radiation continuously tunable over the 1.08-1.25  $\mu$ m wavelength range were generated experimentally by pumping the  $LiF:F_2^-$  crystal with trains of 45-55 pulses, average duration and energy of these pumping pulses being 8 ps and 2 mJ respectively. Pulses emitted at the  $\lambda = 1.15 \mu$ m wavelength were shorter than 0.5 ps and had a peak power of the order of 10 MW. The authors thank V. P. Degtyareva and V. N. Platonov for assisting in evaluation of the results, also A. A. Ishchenko and A. I. Tolmachev for supplying the dye. Figures 3; references 11: 7 Russian, 4 Western.

2415/12947  
CSO: 1862/77

OPTICAL BREAKDOWN OF AEROSOLS BY ACTION OF PULSED CO<sub>2</sub>-LASER

Moscow KVANTOVAYA ELEKTRONIKA in Russian Vol 13, No 11, Nov 86 (manuscript received 15 Aug 85) pp 2208-2215

[Article by A. Ye. Negin, V. P. Osipov, and A. V. Pakhomov, Scientific Research Institute of Physical Chemistry imeni L. Ya. Karpov, Moscow]

[Abstract] Optical breakdown of thermally refractory and optically transparent aerosol particles by a radiation pulse of a CO<sub>2</sub>-laser is analyzed theoretically, of particular concern being the initial stage prior to formation of excess defects. The problem of heating by a microsecond radiation pulse is formulated for spherical Al<sub>2</sub>O<sub>3</sub> and MgO particles, both materials having similar thermo-physical properties but different optical properties at the 10.6  $\mu$ m wavelength. The temperature dependence of the specific heat and the complex refractive index is accounted for. The heat balance equation generally includes not only loss due to radiation but also loss due to conduction through the gas, the latter loss being a function of the temperature dependent on the Knudson number but found to be negligible in this case over the entire  $0.1 \lesssim N_{Kn} \lesssim 8$  range.

The equation of heat balance is accordingly formulated separately for three successive time intervals within the pulse duration: heating to the melting point, complete melting, heating to evaporation up to the boiling point. The form of the radiation pulse is approximated as a piecewise-linear one. Solution of the problem by numerical simulation with the laser radiation intensity varied over the  $10^7 - 10^9$  W/cm<sup>2</sup> range has revealed that both the breakdown threshold and the breakdown time depend on the material but not on the size of aerosol particles. A subsequent experiment with a pulsed CO<sub>2</sub>-laser irradiating aerosol particles of the 0.5  $\mu$ m size fraction has generally confirmed the theoretical results. Accordingly, breakdown of a dielectric aerosol particle is initiated already before the boiling point has been reached. The authors thank A. A. Lushnikov for discussion. Figures 4; tables 1; references 21: 10 Russian, 11 Western (1 in Russian translation).

2415/12947

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## EXCIPLEX KrF-LASER PUMPED BY ION BEAM

Moscow KVANTOVAYA ELEKTRONIKA in Russian Vol 13, No 11, Nov 86 (manuscript received 9 Sep 85) pp 2191-2202

[Article by M. S. Artyev, F. V. Bunkin, V. I. Derzhiyev, A. N. Didenko, A. V. Kozhevnikov, S. S. Sulakshin, V. A. Yurovskiy, and S. I. Yakovlenko, Institute of General Physics, USSR Academy of Sciences, Moscow]

[Abstract] An experimental study of lasing mixtures Kr-F<sub>2</sub> and He-Kr-F<sub>2</sub> with proton-beam pumping was made, for a determination of attainable performance

characteristics and optimum mixture compositions. The mixtures were pumped by 0.9-1 MeV proton beams from a "Tonus" accelerator, with maximum current density of 30 A/cm<sup>2</sup> in pulses of 50 ns width at the 50% level. The gas pressure was varied over the 0.2-2.8 atm range, both He and Kr being 99.998% pure but F<sub>2</sub> containing 1.5% O<sub>2</sub> and up to 5% HF. Subsequent theoretical analysis of such lasers is based on a kinetic model involving plasma components He<sup>+</sup>, He<sub>2</sub><sup>+</sup>, He\*, He<sub>2</sub><sup>\*</sup>, Kr<sub>2</sub><sup>+</sup>, Kr\*, Kr<sub>2</sub><sup>\*</sup>, F<sup>-</sup>, F, KrF\*, Kr<sub>2</sub>F\* and 100 possible plasmachemical reactions, among them 36 Penning reactions. The model has been constructed in the form of ordinary differential equations describing the concentrations and the electron temperatures of those components as well as the quanta of emitted radiation as functions of time, taking into account the temperature dependence of reaction rates. Solution of these equations on a YeS-1052 computer with use of the STIFF program has yielded the sought data covering an initial time period of 100 ns. The results indicate the feasibility of KrF and Kr-F<sub>2</sub> lasers emitting pulses with an energy of 40 J per liter of mixture and at an efficiency of 8-8.5%, the optimum mixture being He:Kr:F<sub>2</sub> = 230:66:1 or Kr:F = 60:1. The theoretical results indicate that the performance, including efficiency, can be improved by means of higher pumping power beyond the 12 MW/cm<sup>2</sup> level reached in the experiment. The experimental results indicate no saturation of output energy with increasing current density of the proton beam. Figures 6; tables 1; references 19: 14 Russian, 5 Western (1 in Russian translation).

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#### EXPERIMENTAL AND DESIGN-THEORETICAL STUDY OF PULSED MOLECULAR CF<sub>4</sub>-LASER

Moscow KVANTOVAYA ELEKTRONIKA in Russian Vol 13, No 11, Nov 86 (manuscript received 20 Aug 85) pp 2167-2175

[Article by V. Yu. Baranov, D. D. Malyuta, Yu. V. Petrushevich, A. I. Starostin, A. P. Streltsov, and S. V. Khomenko, Institute of Atomic Energy imeni I. V. Kurchatov, Moscow]

[Abstract] An experimental study of a pulsed molecular CF<sub>4</sub>-laser was made, for the purpose of determining its energy characteristics and designing its operation under conditions of collisional broadening of spectral lines. The experimental CF<sub>4</sub>-laser was pumped by a hybrid CO<sub>2</sub>-laser consisting of a high-pressure cell with nonself-sustained discharge and a low-pressure discharge cell followed by a stable two-pass resonator. The vibrational-rotational transition of a CO<sub>2</sub>-molecule was selected by means of a diffraction grating with 150 lines/mm, the radiation being extracted through a Ge wedge for pumping the CF<sub>4</sub>-laser at the 9R 12 line after passage through another diffraction grating with 75 lines/mm and a plane-parallel KRS-5 plate with an R = 0.33 bilateral reflection coefficient. The energy characteristics of the CF<sub>4</sub>-laser

and the pumping radiation were measured with calorimeters, the waveform was recorded by semiconductor photomultipliers. Theoretical calculations are based on a  $\text{CF}_4$ -molecule as one in the  $T_d$  symmetry class of spherical rotators, with four vibration modes: one nondegenerate ( $\nu_1$ ), one doubly degenerate ( $\nu_2$ ), two triply degenerate ( $\nu_3, \nu_4$ ). The mathematical steady-state model contains equations of population equilibrium at rotational sublevels, Bloch equations for the density matrix in the approximation of slow variables describing interaction of light and the active medium, and a system of equations describing propagation of a light pulse through a resonator cavity. The complete mathematical model includes also a system of equations of kinetics. Calculations have been made, assuming that the dipole moment of transition from the lower laser level is equal to the dipole moment of pumping transition with some frequency mismatch between these transitions. These calculations have yielded energy characteristics, including reflection losses and relaxation effects. The results indicate a dominant role of two-photon processes. Both experiments and theory confirm the feasibility of a 1 MW  $\text{CF}_4$ -laser emitting pulses of  $0.5 \text{ MW/cm}^2$  intensity at a frequency of  $615 \text{ cm}^{-1}$ , with a pumping intensity of  $4 \text{ MW/cm}^2$  and a gas pressure of 10 torr. Higher laser power should be attainable when the pumping power and the pressure of the active medium (pure  $\text{CF}_4$ ) are simultaneously raised. Figures 6; references 11:

2 Russian, 9 Western.

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# QUASI-CONTINUOUSLY PUMPED PARAMETRIC GENERATOR OF PICOSECOND LIGHT PULSES TUNABLE OVER WIDE RANGE WITHOUT RESONATOR

Moscow KVANTOVAYA ELEKTRONIKA in Russian Vol 13, No 11, Nov 86 (manuscript received 28 Jul 86) pp 2165-2166

[Article by R. Danelys, A. Piskarskas, V. Sirutkaytis, V. Smilgyavichyus, A. Umbrasas, and I. Yuodishyus, Vilnyus State University imeni V. Kapsukas]

[Abstract] The first parametric optical oscillator generating picosecond pulses at repetition rates up to 4 kHz has been activated in a 1 cm long highly nonlinear  $\text{Ba}_2\text{NaNb}_5\text{O}_{15}$  crystal, a superluminescent one without cavity, continuously tunable over the 0.74-1.91  $\mu\text{m}$  wavelength range with quasi-continuous pumping by 200 kW and 50 ps second-harmonic radiation pulses from a  $\text{YAG:Nd}^{3+}$  laser. The pumping radiation is split into two channels, its energy being divided between them in a 1:1.5 ratio. The oscillator generates superluminescence signals of 1-3 nJ energy upon the first pass, with the pumping radiation focused to an average intensity of 45-55  $\text{MW/cm}^2$ . These

signals are amplified by a factor of  $2 \cdot 10^3$  upon the second pass, with the pumping radiation focused to an average intensity of 65-75 MW/cm<sup>2</sup>. The overall efficiency of energy conversion in two passes near degeneracy (ratio of pumping wavelength to difference wavelength  $k = 0.5$ ) is 0.8% with variable-intensity pumping pulses or 1-2% with pumping pulses within the range of linear parametric interaction. Parametric interaction, attainable with approximately 10 maximum-intensity out of approximately 30 pumping pulses in a train, produces emission pulses of 15-40 ps duration depending on the extracted pumping pulses and longer pulses being produced at a higher efficiency by non-linear parametric interaction. The width of the emission spectrum is approximately 100 cm<sup>-1</sup> near degeneracy. Measurements were made with a spectrophotometer in an AGAT-SF-1 electron-optical chamber. Figures 2; references 4: 2 Russian, 2 Western.

2415/12947

CSO: 1862/77

#### EMISSION OF PICOSECOND PULSES BY HETEROJUNCTION INJECTION LASERS WITH Q-SWITCHING

Leningrad PISMA V ZHURNAL TEKHNIЧЕСКОY FIZIKI in Russian Vol 12, No 18, 26 Sep 86 (manuscript received 27 Jun 86) pp 1093-1098

[Article by Zh. I. Alferov, A. B. Zhurvalev, Ye. L. Portnoy, and N. M. Stelmakh, Institute of Engineering Physics imeni A. F. Ioffe, USSR Academy of Sciences, Leningrad]

[Abstract] Emission characteristics of the AlGaAs/GaAs laser with a saturable absorber region for Q-switching were studied in an experiment, concerning the feasibility of stable "spike" emission. Saturable absorber regions in laser specimens were produced by deep implantation of oxygen ions in one mirror of the continuous stripe structure, rather than by its bombardment with protons, so as to avoid amorphization. Oxygen ions of up to 18.7 MeV energy were extracted from the accelerator of the cyclotron at the Institute of Engineering Physics for implantation with doses up to the order of  $10^{11}$  cm<sup>-2</sup> to a depth of approximately 10  $\mu$ m could be reached. Measurement of the power-current characteristic revealed two groups of implanted lasers, the quantum efficiency of the first group decreasing sharply with increasing implantation dose and that of the second group remaining approximately constant. Continuous spike emission was achieved with the second group at repetition rates up to 5 GHz. Spike trains as well as single spikes were recorded with an S1-91/4 stroboscopic oscillograph for evaluation, using a G5-48 pulse generator and a set of interchangeable photoresistor detectors. Emission pulses of 60 ps half-width were detected by an InP<Fe> photoresistor. The true pulse duration, taking into account the resolution time of the instruments, was estimated by the autocorrelation method with an "Applied Physics Co" PS-30 correlator. The time interval between successive spikes on the autocorrelation curve corresponds to the time of double passage of photon through a Fabry-Perot resonator used with the laser diode, and their width corresponds to the

spectral width of the envelope of laser emission modes. The authors thank G. M. Gusinskiy for performing the ion implantation. Figures 3; references 4: 2 Russian, 2 Western.

2415/12947  
CSO: 1862/35

UDC 537.52:621.375.82

# INSTABILITY OF SPATIAL UNIFORMITY OF SELF-SUSTAINED DISCHARGE IN EXCIMER LASERS

Moscow TEPILOFIZIKA VYSOKIKH TEMPERATUR in Russian Vol 24, No 6, Nov-Dec 86  
(manuscript received 27 Jun 85) pp 1072-1078

[Article by V. M. Borisov, V. P. Novikov, and O. B. Khristoforov, Moscow]

[Abstract] Self-sustained volume discharge with current stabilization in excimer gas lasers employing halides of noble gases is analyzed theoretically for stability of spatial uniformity, taking into account stepwise ionization as a destabilization mechanism. Experimental data on loss of spatial uniformity depending on the composition of the active medium, namely on the concentration of halogen molecules ( $F_2$ ,  $NF_3$ ,  $HC1$ ) and the concentration of heavy noble gas (Kr, Xe) in helium are correlated with theoretical calculations referring to only one mode of excitation with almost constant voltage and current over a long "quasi-steady" segment of the excitation pulse. The condition for stability of spatial uniformity is derived from the equations of kinetics for electrons and electron-excited particles (atoms, molecules), their concentration balance including annihilation of excited states during processes of the second kind and stepwise ionization of Kr or Xe atoms, assuming additionally that changes in perturbations of the excited-particle concentration remain quasi-steady during changes in perturbations of the electron concentration. Interpretation of the experimental data on this basis reveals an only partial saturation or smoothing of the excited-particle concentration, which indicates that loss of spatial uniformity during quasi-steady excitation can be prevented by lowering the concentration of halogen molecules but not below the level necessary for sufficient generation of excimer molecules. Figures 1; references 14: 6 Russian, 8 Western.

2415/12947  
CSO: 1862/102

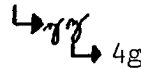


DISCOVERY OF NARROW MESON WITH 1750 MeV MASS DECAYING INTO TWO  $\eta$ -MESONS

Moscow PISMA V ZHURNAL EKSPERIMENTALNOY I TEORETICHESKOY FIZIKI in Russian  
Vol 44, No 10, 25 Nov 86 (manuscript received 2 Oct 86) pp 441-444

[Article by S. V. Donskov, A. V. Inyakin, D. B. Kakauridze, V. A. Kachanov, A. V. Kulik, A. A. Lednev, Yu. V. Mikhaylov, Yu. D. Prokoshkin, Yu. V. Rodnov, S. A. Sadovskiy, V. D. Samoylenko, A. V. Singovskiy, V. P. Sugonyayev, G. V. Khaustov, P. M. Shagin, and A. V. Shtannikov, Institute of High-Energy Physics, Serpukhov (USSR), D. Alde and E. A. Knap, Los Alamos National Laboratory, New Mexico (USA), F. Binon, K. Brikman, T. Muthieu, and G. P. Stroot, Institute of High-Energy Physics, Brussels (BELGIUM), M. Goïnerre and G. P. Penier, Laboratory of High-Energy Physics, Ancy (FRANCE), Joint IHEPh (Serpukhov) - CERN Experiment]

[Abstract] The study of the  $\eta\eta$ -system in the  $\pi^- p \rightarrow M^0 n$  reaction, begun



with discovery of the scalar G(1590)-meson in the 1983 experiment, has in a recent experiment revealed a narrow, less than 50 MeV wide, sharp peak within the 1750 MeV range of the  $\eta\eta$ -mass spectrum corresponding to a new meson with a  $1755 \pm 8$  MeV mass. Measurements were made with the same GAMS-2000 multiphoton hodoscopic spectrometer, using a 38 GeV/s pion beam extracted from the accelerator at the Institute of High-Energy Physics (Serpukhov, USSR). The rare reaction was detected on the basis of 45,000 events resulting in four  $\eta$ -quanta in the final state. The cross-section for the  $\pi^- p \rightarrow X(1750)n$  reaction yielding this new meson is very small, only  $3.5 \pm 1.5$  nb. This new meson decays into two  $\eta$ -mesons. The integral t-distribution of  $\eta\eta$ -events within that peak as well as the angular distribution of the  $\eta\eta$ -system were determined, the latter found to become less mass dependent and more isotropic in the  $|t| \geq 0.3$  (GeV/s)<sup>2</sup> range of momentum transfer. Since only even states are possible in this system, such an isotropy indicates  $J^{PC} = 0^{++}$  spin parity or a less likely but also possible  $2^{++}$  state. Interesting for further study should be existence of another narrow state a 2220 MeV mass. The authors thank S. S. Gershteyn, A. A. Logunov, and V. F. Obraztsov for discussion of the results. Figures 3; references 19: 10 Russian, 9 Western.

2415/12947

CSO: 1862/78

# THRESHOLD FORM OF ENERGY DEPENDENCE OF PARAMETRIC X-RADIATION EMISSION

Leningrad PISMA V ZHURNAL TEKHNIЧЕСКОY FIZIKI in Russian Vol 12, No 24,  
26 Dec 86 (manuscript received 26 May 86) pp 15-7-1511

[Article by Yu. N. Adishev, R. D. Babadzhanov, T. M. Muminov, S. A. Vorobyev,  
B. N. Kalinin, V. V. Mun, S. Pak, G. A. Pleshkov, and A. P. Potylitsyn]

[Abstract] Emission of quasi-monochromatic x-radiation by ultrarelativistic electrons passing through a diamond crystal was discovered in an earlier experiment (ZHURNAL EKSPERIMENTALNOY I TEORETICHESKOY FIZIKI Vol 41, 1985). In a later experiment (ZHURNAL EKSPERIMENTALNOY I TEORETICHESKOY FIZIKI Vol 90, 1986) were studied its spectral characteristics and in the latest equipment were studied its energy characteristics. The target, a 0.35 mm thick diamond single crystal, was placed in the inner electron beam of the Tomsk synchrotron for bombardment of its (100) planes at a  $44.14^\circ$  angle so that the electron beam formed a  $0.06^\circ$  angle with the (001) planes and a  $0.86^\circ$  angle with the  $\langle 100 \rangle$  axis, both angles much larger than the corresponding critical (Lyndhardt) angles. The photon yield was measured by a Xe-filled counter with a 0.15 mm thick Be window, 500 mm behind the crystal, while the electron energy was varied over the 150-900 MeV range. The results reveal a 300 MeV emission threshold, compared with the 320 MeV theoretical one, and a flat photon yield above it. Diffraction of photons should make the photon yield vary monotonically with varying electron energy. Attenuation of bremsstrahlung according to the inverse-squared law indicates a parametric mechanism of emission of monochromatic x-radiation in the Bragg directions by a charged particle passing through a crystal. The authors thank A. N. Didenko for collaboration and for discussion of the results. Figures 2; references 8: 5 Russian, 3 Western.

2415/12947

CSO: 1862/89

UDC 539.171.017

# CROSS-SECTION FOR INELASTIC INTERACTION OF NUCLEONS AND PIONS WITH C AND Pb NUCLEI RELEASING ENERGY OF 0.5-5.0 TeV

Moscow IZVESTIYA AKADEMII NAUK SSSR: SERIYA FIZICHESKAYA in Russian Vol 50,  
No 11, Nov 86 pp 2084-2086

[Article by V. A. Avakyan, S. R. Gevorgyan, V. M. Zhamkochyan, G. V. Karagezryan, M. I. Keropyan, E. A. Mamidzhanyan, and R. M. Martirosov, Yerevan Institute of Physics]

[Abstract] The cross-section for inelastic interaction of nucleons and pions with C and Pb nuclei releasing an energy higher than 500 GeV was measured in the "Pion" facility, in the course of experiments for which this facility had been redesigned in 1981. For the purpose of statistical analysis, interaction events were grouped into three energy ranges: 0.5-1.0 TeV, 1.0-2.0 TeV, 2.0-5.0 TeV. The cross-sections were then calculated for a proton and for a

neutral pion, with appropriate correction for effects influencing measurements made with an ionization calorimeter and a detector of transient x-radiation. These calculations, based on the theory of multiple scattering, have yielded an energy dependence of the cross-section for each pair of interacting particles (pC-, pPb-,  $\pi$  C-,  $\pi$  Pb-) describable by the general relation  $\sigma^{\text{in}}(E) = A + B \cdot \log^2 E$  and also the parameters  $\sigma_0, \alpha$  for a proton and for a neutral pion in the powerlaw dependence  $\sigma^{\text{in}} = \sigma_0 A^\alpha$  of the cross-section for interaction (at any energy level above 0.5 TeV) on the atomic number A of the target element. Figures 2; tables 1; references 5: 2 Russian, 3 Western.

2415/12947  
CSO: 1862/90

#### ELECTRON-NUCLEAR DOUBLE RESONANCE IN NONUNIFORM MAGNETIC FIELD

Moscow ZHURNAL EKSPERIMENTALNOY I TEORETICHESKOY FIZIKI in Russian Vol 91, No 3(9), Sep 86 (manuscript received 20 Feb 86) pp 1030-1036

[Article by S. S. Ishchenko, Institute of Semiconductors, UkSSR Academy of Sciences]

[Abstract] Electron-nuclear double resonance in a nonuniform magnetic field and its applicability to introscopy for flaw detection are analyzed on the basis of theoretical relations and experimental data, this resonance combining the high resolution of nuclear-magnetic resonance and the high sensitivity of electron-paramagnetic resonance. For theoretical analysis, the frequency-dependent ENDR signal is expressed as a volume integral of the product of three functions: space distribution of paramagnetic centers, field-dependent form function of the EPR line, frequency-dependent form function of the NMR line corresponding to the nuclear transition associated with the EPR. The nonuniform magnetic field is characterized as the sum of a uniform one  $H_0$  ( $H_0$  - magnetic field intensity at resonance and an increment  $\Delta H$ . In the practical case of a linearly nonuniform magnetic field, with a uniform gradient in any one direction only, the volume integral reduces to a line integral. The experiment was performed with a superheterodyne spectrometer in the 3 cm wave band at room temperature and at a microwave frequency of 9400 MHz, a linearly nonuniform magnetic field being produced in the direction normal to a constant magnetic field by means of two wedges as pole shoes on the electromagnet. The variation of the magnetic field intensity in the gap was monitored with a Hall probe. This instrument was used for inspection of LiF single crystals with F-center, cuboidal specimens  $4 \times 4 \text{ mm}^2$  in cross-section and 4.7 mm long having been placed in the magnetic field with the long edges parallel to it so that the vector of the constant magnetic field was lying in a (001) cross-section plane of the crystal at a  $45^\circ$  angle to its [100] axis. Double resonance was recorded not only on  $^7\text{Li}$  nuclei but also on  $^{19}\text{F}$  nuclei in various coordination spheres surrounding an F-center, with essentially similar spectra.

Further measurements were therefore made using only signals from nuclei of the  $^7\text{Li}$  isotope, near its Larmor frequency. Reduction of the crystal size to a  $2 \times 2 \text{ mm}^2$  cross-section only lowered the intensity of the spectrum, without changing its form. The results reveal that the form of signals from wide EPR lines and from narrow NMR lines coincides with the distribution of paramagnetic centers over the volume of the crystal specimen. Double resonance can be focused in space without special devices when the EPR lines are narrow, and signals from a segment of the specimen within the zone of resonance magnetic field intensity become amplified while the form of their spectrum depends on the location of "placement on the EPR line". To these advantages of the ENDR method from the standpoint of introscopy must be added that the spectrum is recorded with the magnetic field and thus also its gradient remaining constant during the process, that directly the absorption line and not its derivative is recorded, which greatly simplifies the data processing, and that the large number of ENDR lines belonging to nuclei of different kinds or to nuclei of the same kind in different coordination spheres but nevertheless carrying the same information offers the possibility of optimizing the inspection procedure while providing a large number of independent equations for mathematical evaluation of the data. The author thanks S. M. Okulov for assisting in construction of the wedges and A. B. Brik, V. G. Grachev, A. B. Roytsin for discussing the project. Figures 5; references 10: 8 Russian, 2 Western.

2415/12947

CSO: 1862/34

## OPTICS AND SPECTROSCOPY

### ACOUSTOOPTICAL PROPERTIES OF RARE EARTH AND GALLIUM GARNETS

Leningrad PISMA V ZHURNAL TEKHNIЧЕСКОY FIZIKI in Russian Vol 12, No 23,  
12 Dec 86 (manuscript received 17 Aug 86) pp 1409-1411

[Article by A. A. Danilov, Ye. V. Zharikov, M. Yu. Nikolskiy, V. V. Osiko,  
A. M. Prokhorov, and I. A. Shcherbakov]

[Abstract] Available data on relevant properties of five rare earth and gallium garnets (Y-Gd-Ga<Er>, Gd-Ga, Gd-Sc-Ga<Er>, Gd-Sc-Ga<Cr><Nd>, La-Nd-Lu-Ga), including the refractive index at the 1.06  $\mu\text{m}$  wavelength and the acoustic velocity, indicate that they have excellent characteristics needed for diffraction of light waves by ultrasonic shear waves, no matter how the light is polarized. An experimental study was made with Gd-Sc-Ga<Cr<sup>3+</sup>><Nd<sup>3+</sup>> as such an acoustooptic modulator for diffraction of light from a He-Ne laser at the 1.15  $\mu\text{m}$  wavelength by ultrasound with a center frequency of 52.6 MHz from a LiNbO<sub>3</sub> piezoelectric converter, the latter being excited by a 10 W sine-wave voltage generator. Measurements have revealed that such a garnet crystal has a  $1.8 \pm 0.2$  higher figure of merit than fused quartz. Tables 1; references 4: 3 Russian, 1 Western.

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CSO: 1862/83

UDC 535.194

### MEASUREMENT OF DIPOLE MOMENTS OF MOLECULES BY MODULATION STARK SPECTROSCOPY OF DIPS

Leningrad OPTIKA I SPEKTROSKOPIYA in Russian Vol 61, No 4, Oct 86 (manuscript received 13 Jan 86) pp 756-760

[Article by O. N. Korotayev, A. I. Yurchenko, and V. P. Karpov]

[Abstract] A simple modification of modulational Stark spectroscopy of dips cut by laser radiation in nonuniformly widened absorption spectra of solutions is proposed, namely a polarizational variant of this method, for determining the angle between vector  $\Delta\mu$  (change of electric dipole moment) and vector  $d$

(electric dipole moment of a transition) at various orientations of the light polarization vector. The underlying theory of the Stark effect here is based on an exact rather than approximate analysis of the field dependence of a dip, considering that this dependence is not a weak one. The depth of a dip is calculated accordingly, taking into account that an external electric field shifts the frequency of 0-0 transition in every molecule. In the case of a harmonically oscillating electric field the depth of dip becomes a function of not only the field amplitude but also of time and so does the intensity of light passing through a solution at the frequency of laser action. An experiment was performed with  $\sim 10^{-3}$  M/l solutions of polyvinyl chloride (PVC) and of octaethyl polyvinyl chloride (OEPVC) in polymethyl methacrylate, 50  $\mu\text{m}$  thick films of these materials having been glued with Canada balsam between two parallel glass plates so as to prevent their electrical breakdown and so placed transversely between two plane electrodes. The amplitude of the sinusoidally alternating electric field intensity was allowed to reach  $5 \cdot 10^4$  V/cm and for PVC and  $2.5 \cdot 10^4$  V/cm for OEPVC, with the frequency of the applied voltage 215 Hz and 260 Hz respectively. Cuts in the absorption spectra were made by circularly polarized radiation of  $0.2 \text{ W/cm}^2$  intensity from a He-Ne laser ( $\lambda = 632.8 \text{ nm}$  wavelength). The results confirm the feasibility of determining by this method both the magnitude and the orientation of the  $\Delta\mu$  vector as well as, inversely, the characteristics of shallow dips when that vector is known. Figures 3; references 11: 3 Russian, 8 Western.

2415/12947  
CSO: 1862/55

UDC 535.0

#### IMAGE OF SUN BELOW HORIZON AS SEEN FROM OUTER SPACE

Leningrad OPTIKA I SPEKTROSKOPIYA in Russian Vol 61, No 4, Oct 86 (manuscript received 27 May 86) pp 905-907

[Article by T. M. Bandman and S. G. Rautian]

[Abstract] An earlier interpretation of the phenomenon observed by astronauts during sunrise, namely seeing not only the part of the solar disk above the horizon but also its symmetric image below the horizon, is disproved by calculations for a convex spherical mirror in the Earth atmosphere. These calculations show that no object with a spherical symmetry as that of the Earth surface can at low sliding angles possibly form an image of a light source symmetrically with respect to the horizon. Figures 2; references 6: all Russian.

2415/12947  
CSO: 1862/55

## BRAGG DIFFRACTION OF LIGHT BY STANDARD SOUND WAVE

Leningrad OPTIKA I SPEKTROSKOPIYA in Russian Vol 61, No 4, Oct 86 (manuscript received 27 Jan 86) pp 885-888

[Article by Ye. G. Ananyev, V. E. Pózhár, and V. I. Pustovoyt]

[Abstract] Bragg diffraction of light by a standing sound wave in uniaxial crystals is analyzed, specifically collinear diffraction, assuming that the sound wave modulates the dielectric permittivity of the crystal material and behaves like a stationary grating which oscillates parallel to the optical axis. The corresponding two-dimensional system of two first-order partial differential equations is solved for longitudinal and transverse light waves with slowly varying amplitudes, expandable into harmonic series. The result indicates that these equations are valid for standing sound waves whose time frequency need not be much lower than the group velocity of light waves divided by the optical coherence length in the crystal, as long as it is much lower than the reciprocal of the group delay time of light waves. The analysis can be extended to noncollinear diffraction as well. Figures 1; references 7: 3 Russian, 4 Western.

2415/12947  
CSO: 1862/55

UDC 535.317.1

## RANDOM SHIFTS OF OPTICAL IMAGE UPON REFLECTION BY LAMBERT SURFACE IN TURBULENT ATMOSPHERE

Leningrad OPTIKA I SPEKTROSKOPIYA in Russian Vol 61, No 4, Oct 86 (manuscript received 18 Jun 85) pp 839-844

[Article by V. P. Aksenov, V. A. Banakh, V. L. Mironov, I. N. Smalikho, and B. N. Chen]

[Abstract] Reflection of a laser beam by a radar target with a diffusely reflecting surface is considered and the resulting random shifts of the target image are analyzed, assuming negligible random shifts caused by atmospheric turbulence. This assumption is valid when the apertures of the transmitter and the receiver telescope match the aperture of the reflector with respect to diffraction characteristics. The dispersion of those random shifts is calculated for a source with a Gaussian field distribution in the transmitter aperture, taking into account that both atmospheric turbulence and space-time fluctuation of the reflection coefficient cause the complex amplitude of waves reflected by the target to be a random quantity. Each term in the general expression is evaluated in terms of system parameters and the dispersion, normalized to the transmission coefficient of the receiver telescope, is calculated and plotted as a function of the characteristic target dimension.

The extreme cases are a point target and an infinitely large one. Particularly interesting is a receiver which "follows up" instantaneous changes of the reflection coefficient. In this case, with a certain relation between transmitter, target, and telescope apertures, the dispersion of random image shifts is attributable principally to random scattering of incident waves by the target surface. Figures 2; references 10: 9 Russian, 1 Western.

2415/12947  
CSO: 1862/55

UDC 535.42

# MULTISTAGE DIFFRACTION OPTICS IN SEMICOHERENT LIGHT: ANALYSIS OF LAU AND TALBOT EFFECTS BY CONVOLUTION METHOD

Leningrad OPTIKA I SPEKTROSKOPIYA in Russian Vol 61, No 4, Oct 86 (manuscript received 12 Mar 86) pp 821-827

[Article by A. P. Smirnov]

[Abstract] Diffraction of light passing through a sequence of planes and the spaces between them, with multiplicative amplitude-phase transformation of the wavefront, is analyzed by the Fourier-Fresnel convolution method. First the Lau effect is considered in a system with two gratings. Here light from a large source passes through a focusing lens and strikes the first grating, whereupon the interference fringes appear in the focal plane of another lens behind the second grating. From the 3-stage diffraction operator describing the Lau effect in such a system is derived an expression for the intensity of Lau fringes. This expression simplifies when extended to the Talbot effect involving self-reproduction in such a system with a spherical wave from a point source. The geometrical configuration and the physical conditions for achieving the Lau effect and the Talbot effect experimentally are determined on this basis. The invariance property of multistage diffraction optics, established as a result, is analogous to the parallax approximation in geometrical optics. Figures 1; references 16: 2 Russian, 14 Western (3 in Russian translation).

2415/12947  
CSO: 1862/55



## OPTICAL PROPERTIES OF EULITINES

Tomsk IZVESTIYA VYSSHIKH UCHEBNIKH ZAVEDENIY: FIZIKA in Russian Vol 29,  
No 10, Oct 86 (manuscript received 22 Apr 85) pp 113-115

[Article by O. A. Gudayev, V. A. Gusev, S. A. Petrov, N. A. Chetvergova, and  
A. V. Kosov, Krasnoyarsk State University, Institute of Automation and  
Electrometry, Siberian Department, USSR Academy of Sciences]

[Abstract] A study of sillenites  $6\text{Bi}_2\text{O}_3 \cdot 1\text{MO}_2$  ( $\text{M} = \text{Si, Ti, Ge}$ ) and eulitines  $2\text{Bi}_2\text{O}_3 \cdot 3\text{MO}_2$  ( $\text{M} = \text{Ge, Zr}$ ) was made for a determination of their optical properties. Crystals of sillenites  $\text{Bi}_{12}\text{SiO}_{20}$ ,  $\text{Bi}_{12}\text{TiO}_{20}$ ,  $\text{Bi}_{12}\text{GeO}_{20}$ ,  $\text{Bi}_{12}\text{GeO}_{20}$  (A1) and eulitines  $\text{Bi}_4\text{Ge}_3\text{O}_{12}$ ,  $\text{Bi}_4\text{Zr}_3\text{O}_{12}$  were grown from stoichiometric melts by the Czochralski method and then annealed in an oxygen atmosphere, whereupon 0.3-1.0 mm thick specimens were cut for measurements. Also  $\text{Bi}_4\text{Zr}_3\text{O}_{12}$  glass was included in the study. The sillenites were yellow and the eulitines were transparent. Their absorption spectra were measured at a temperature of 298 K, with a deuterium or KGM-24-150 lamp as source including an MDR-23 monochromator and an FEU-36A or FEU-79 photomultiplier as receiver. Their reflection spectra were measured at the same temperature and with the same equipment plus an aluminum mirror. Their photoluminescence spectra and thermoluminescence curves were measured over the 80-300 K temperature range, their luminescence excitation spectra were measured at 80 K and 300 K. The results indicate that the valence band of sillenites and eulitines is identically filled with Bi electrons, the width of the forbidden band not depending on the nature of the other oxide but being determined by the ratio  $\text{Bi}_2\text{O}_3:\text{MO}_2$  and decreasing as with higher  $\text{MO}_2$  content. The thermoluminescence curves of eulitines were found to have two strong peaks, the lowest levels in the conduction band being evidently more depleted of trap states than the conduction band of sillenites. The low photoconductivity of sillenites is evidently attributable to intense entrapment of charge carriers, as indicated by their thermoluminescence curves. Figures 4; references 12: 5 Russian, 7 Western.

2415/12947

CSO: 1862/75

PICOSECOND SPECTROSCOPY OF NONLINEAR OPTICAL ACTIVITY AND NONLINEAR ABSORPTION  
IN GaAs

Moscow ZHURNAL EKSPERIMENTALNOY I TEORETICHESKOY FIZIKI in Russian Vol 91,  
No 3(9), Sep 86 (manuscript received 13 Feb 86) pp 984-1000

[Article by S. A. Akhmanov, N. I. Zheludev, and R. S. Zadoyan, Moscow State  
University imeni M. V. Lomonosov]

[Abstract] Polarizational self-action of light in crystals and specifically cubic ones, a case of nonlinear optical activity manifested in intensity-dependent rotation of the polarization plane, is analyzed from the standpoint of application to spectroscopy and particularly to study of GaAs crystals. Two mechanisms, the dispersive one based on nonlocality of the nonlinear response and the dissipative one based on polarization dependence of nonlinear absorption, are cooperative here and their contributions are comparable in magnitude near exciton absorption resonance, which makes them easily separable for evaluation. A picosecond polarimeter-densitometer has been developed for such a spectroscopy involving measurement of anisotropy and nonlinear absorption. Its optical part consists of a parametric light source, a space-transform filter, a polarizer and analyzer pair of Glan prisms respectively before and behind a cryostat with temperature control over the 100-300 K range and with a neutral filter placeable on either side, one directly fed photoreceiver and three photoreceivers fed through a light-beam splitter each. The instrument has been automated on the basis of an Elektronika D3-28 microcomputer. Experiments were performed with a  $\text{LiNbO}_3$  crystal (1.6-1.9  $\mu\text{m}$  wavelengths) or a  $\text{LiIO}_3$  crystal (0.8-0.9  $\mu\text{m}$  wavelengths) and a pumping pulsed YAG- $\text{Nd}^{3+}$  laser as 2-stage superluminescent light source, angle adjustment of the crystals yielding respectively 60-20  $\text{cm}^{-1}$  and 12  $\text{cm}^{-1}$  wide emission spectra. This instrument was used for determining the frequency dispersion of nonlinear gyrotropy and of nonlinear magnetic anisotropy near one-photon and two-photon resonances of interband absorption, also for recording and analyzing high levels of nonlinearities based on various mechanisms such as line saturation in the discrete spectrum of free excitons and "giant" depolarization with attendant shielding of excitons. For reference, experiments were also performed at the  $\lambda = 1.06 \mu\text{m}$  wavelength, near the edge of the fundamental absorption band, at a temperature of 300 K. The authors thank Z. M. Kostov for discussion. Figures 11; references 33: 15 Russian, 18 Western.

2415/12947  
CSO: 1862/34

## PLASMA PHYSICS

### ANALYSIS OF NONLINEAR ELECTRODYNAMICS IN NONEQUILIBRIUM PLASMA BY EXPANSION WITH RESPECT TO BEAM TRAJECTORY PERTURBATIONS

Moscow ZHURNAL EKSPERIMENTALNOY I TEORETICHESKOY FIZIKI in Russian Vol 91, No 5(11), Nov 86 (manuscript received 1 Apr 83) pp 1620-1632

[Article by M. V. Kuzelev, A. A. Rukhadze, Yu. V. Bobylev, and V. A. Panin, Moscow State University imeni M. V. Lomonosov]

[Abstract] A new method of analyzing nonlinear electrodynamic effects in a nonequilibrium plasma upon excitation by an electromagnetic wave is outlined, this method being based on field equations explicitly including the trajectories of plasma beam particles  $y = y_0 + w(t) + x(y_0, t)$  ( $w$  - displacement caused by forward motion and average force,  $\tilde{x}$  -  $2\pi$ -periodic perturbation by waves and their interaction,  $t$  - time). The nonlinear variables in the corresponding Poisson field equation and equation of excitation, namely wave amplitude and electron concentration, are expanded into power series with respect to those trajectory perturbations, assuming that the latter are small and can be represented in the form of a Fourier series. An analytical solution of the problem is generally possible. It is demonstrated on several simple plasma beam nonlinearities such as uniform or nonuniform plasma beam oscillations, nonlinear dispersion of plasma beam waves, multivelocit plasma beams, and multimode plasma excitation leading to turbulence and instability. Figures 5; references 9: all Russian.

2415/12947  
CSO: 1862/79

### PASSIVATION OF ELECTROACTIVE CENTERS IN GaAs BY STREAM OF HYDROGEN PLASMA

Leningrad PISMA V ZHURNAL TEKHNIЧЕСКОЙ ФИЗИКИ in Russian Vol 12, No 24, 26 Dec 86 (manuscript received 15 Jul 86) pp 1486-1489

[Article by A. A. Balmashnov, K. S. Golovanivskiy, E. K. Kamps, E. M. Omelyanovskiy, A. V. Pakhomov, and A. Ya. Polyakov, 'Friendship of Nations' University imeni Patrice Lumumba]

[Abstract] Hydrogenation of GaAs single crystals by means of a magnetoactive hydrogen plasma, for passivation of electroactive defects, was studied in an

experiment with microwave discharge in a magnetic field as plasma source. Such a discharge was produced inside a quartz tube inside a coaxial hollow cylindrical resonator, with excitation provided by a 700 W - 2.42 GHz continuous-wave magnetron generating a  $TE_{111}$ -mode in the absence of a plasma. Specimens of intrinsic GaAs as well as of n-GaAs crystals doped with Te or Pb were placed inside a reactor chamber normally to the incident plasma stream. Deep centers were analyzed by the method of DLTS capacitive spectroscopy, before and after plasma treatment. Properties of the semiconductor material before and after plasma treatment were measured on the basis of photoluminescence spectra at two temperatures, 300 K and 77 K, microcathodoluminescence spectra, and capacitance-voltage characteristics. The results indicate that treatment with a magnetoactive microwave hydrogen plasma for a period of 15 min, while heating the crystals to 400°C or even 500°C, has lowered the concentration of electrons and fine ionized donor centers by almost three orders of magnitude within a 10  $\mu$ m thick layer. This is much more effective than treatment with a high-frequency plasma capable of passivating an only 1  $\mu$ m thick layer within 2 h. Figures 2; references 4: all Western.

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CSO: 1862/89

#### FILAMENTARY INSTABILITY OF HIGH-CURRENT ION BEAMS IN MAGNETOACTIVE PLASMA

Leningrad PISMA V ZHURNAL TEKHNIЧЕСКОY FIZIKI in Russian Vol 12, No 24,  
28 Dec 86 (manuscript received 26 Jul 86) pp 1473-1476

[Article by V. I. Golota, V. I. Karas, V. A. Kiyashko, Ye. A. Kornilov,  
L. A. Kornilenko, V. A. Vinokurov, and A. A. Nikolayenko, Kharkov Institute of  
Engineering Physics, UkSSR Academy of Sciences]

[Abstract] The evolution of filamentary instability of a high-current ion beam in a magnetoactive plasma was studied in an experiment with ion injection into a gas-filled diode from an inductive ion accelerator. An ion beam with 200 keV pulse energy and 1  $\mu$ s pulse duration was formed in the diode within a magnetic shield with cusp geometry. An aluminum target 10 cm behind the cathode in a magnetic field of 5 kG intensity was bombarded with such an ion beam, whose current density within the interelectrode space was varied smoothly over a wide range. Examination of the target surface under a scanning electron microscope with x8000 magnification revealed a uniform distribution of defects indicating suppression of ion beam instability at current densities up to  $10^2$  A/cm<sup>2</sup> and local craters indicating buildup of ion beam instability at current density of  $10^3$  A/cm<sup>2</sup> or higher. These results correlate with earlier theoretical analysis of filamentary instability of a charge-compensated and current-compensated charged-particle beam in a magnetoactive hot plasma. The authors thank Ya. B. Faynberg for discussion of the results. Figures 2; references 5: 2 Russian, 3 Western.

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CSO: 1862/89

## STUDY OF GENERATION OF HIGH-POWER ION BEAMS IN REFLECTION TRIODE WITH SUPPLEMENTARY PLASMA SOURCE AT ANODE

Moscow FIZIKA PLAZMY in Russian Vol 12, No 9, Sep 86 (manuscript received after revision 15 Nov 85) pp 1113-1119

[Article by V. M. Bysritskiy, A. A. Verigin, S. N. Volkov, Ya. Ye. Krasik and V. I. Podkatov, Scientific Research Institute of Nuclear Physics at Tomsk Polytechnical Institute]

[Abstract] High-power pulse ion beam generators have possible applications for controlled nuclear fusion, lasers and industrial uses and should have short delay times for lasing following the pulse, adjustable emission, low homogeneous plasma temperatures and various Z/M relations. Two series of experiments were carried out on a high-power Vera accelerator (0.5 MeV). In the first series, an ion beam was generated lasting 400 ns with a maximum amplitude of 8 kA while the anode voltage was 100 kV. In the second series, a device was added forming a compound anode and supplying additional plasma. The current discharge reached 20 kA. Three operating modes were possible: a) similar to that of the accelerator (less than 3 microseconds); b) 3-6 microseconds; c) more than 6 microseconds. Measurements by transit-time sensors showed the presence of H, C and Cu ions whose share varied with the length of the generation period (light H ions appeared first). Beam density rose with ion density. Beam macrodivergence was 4-6° at the periphery and  $< 1^\circ$  in the center. Beam efficiency was 20 percent. Figures 6; references 6: 5 Russian, 1 Western.

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CSO: 1862/20

UDC 533.93.95.9.08

## EXCITATION OF CADMIUM IONS IN EXPANDING He-Cd PLASMA

Tomsk FIZIKA in Russian Vol 24, No 7, Jul 86 (manuscript received 14 Jan 85) pp 35-39

[Article by A. A. Babin, I. I. Muravyev, L. D. Shatova and A. M. Yancharina, Siberian Physico-Technical Institute at Tomsk State University]

[Abstract] A gas-discharge plasma source with a TGI1-1000/25 thyatron switch and a 0.5-3 microsecond pulse was used to form He-Cd plasma and the radiation was analyzed by a DAS-2 spectrometer. The space-time distribution of the helium and cadmium spectral lines was studied. The effect of ion recombination is considerable because of the rapid cooling of the plasma dispersion. An afterglow effect is due to energy transmission from long-lasting states of the He atoms and ion. If He is replaced by H or Ar there is a brief rise in cadmium ion intensity after the pulse but no afterglow. Deexcitation processes due to slow electrons also affect the afterglow. Electron temperature and collisions of metastable He and Cd atoms are important. Electron concentration was determined according to the Stark effect broadening of the H line

with an error of less than 10 percent. Electron temperature was evaluated on the basis of He ion radiation. The temperature and concentration data show that the plasma afterglow is suitable for recombination pumping of plasma lasers. Figures 4; references 15: 11 Russian, 4 Western.

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CSO: 1862/2

#### DEVIATION FROM FEYNMAN SCALING IN $\pi$ -A-INTERACTIONS IN SUPERHIGH-ENERGY RANGE

Moscow YADERNAYA FIZIKA in Russian Vol 44, No 5(11), Nov 86 (manuscript received 5 Nov 85) pp 1300-1305

[Article by M. Z. Iofa and A. Ye. Pukhov, Scientific Research Institute of Nuclear Physics, Moscow State University]

[Abstract] The deviation from Feynman scaling in a  $\pi A \rightarrow hX$  reaction as the energy of the incident particle changes from  $E_0$  to  $E$  is calculated according to the Regge theory of strong interactions, taking into account not only that the average number of n-pomeron jets increases with increasing energy (theory of a supercritical pomeron) but also that any fixed energy of the incident particle it is larger in a target with a higher atomic number. Cross-section for production of n-pomeron jets at a nucleus  $A$ , including  $A = {}^1\text{H}, {}^{14}\text{N}$ , and cross-section for diffractive dissociation of the incident particle are calculated according to the quasi-eikonal multicomponent model. Effects associated with preasymptotic energy dependence of the structural functions are excluded by calculation of the quantity  $F^{\pi A \rightarrow hX}(E, E_1, x)$  in the best approximation of parameters  $\sigma_1$  and  $\sigma_2$  ( $E_1$  - energy level at which those effects become negligible). The deviation from Feynman scaling, a consequence of the energy dependence of n-pomeron jet production in the superhigh-energy range, is determined by the probability  $P_n^A(E)$  of that n-pomeron jet production. The authors thank I. P. Ivanenko for support and B. L. Kanevskiy, A. N. Solomin, L. M. Shcheglov, and L. A. Kheyn for discussions. Figures 1; references 15: 5 Russian, 1 Polish, 9 Western.

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PROPERTIES OF LEADING PROTONS AND ANTIPROTONS FROM EXCLUSIVE  $\bar{p}p$ -REACTIONS AT 32 GeV/s

Moscow YADERNAYA FIZIKA in Russian Vol 44, No 5(11), Nov 86 (manuscript received 24 Dec 85) pp 1201-1208

[Article by M. Yu. Bogolyubskiy, A. A. Borovikov, V. A. Bumazhnov, L. L. Zakamskiy, A. I. Kotova, Ye. A. Kozlovskiy, A. Ye. Kiryunin, M. S. Levitskiy, A. A. Minayenko, A. M. Moiseyev, D. I. Patalakha, Ye. A. Starchenko, M. N. Ukhanov, and S. V. Chekulayev, Institute of High-Energy Physics, Serpukhov, E. G. Boos and N. S. Pokrovskiy, Institute of High-Energy Physics, KaSSR Academy of Sciences, Alma-Ata, A. S. Proskuryakov, L. I. Sarycheva, and L. N. Smirnova, Scientific Research Institute of Nuclear Physics, Moscow State University]

[Abstract] Properties of leading protons and antiprotons from exclusive channels  $\bar{p}p \rightarrow \bar{p}p1(\pi^+\pi^-)$  reactions with  $1 \leq 1 \leq 4$  occurring at 32.1 GeV/s are examined on the basis of experimental data and theoretical calculations. The  $\bar{p}p$ -experiment was performed in a Mirabel chamber with a beam of antiprotons extracted from the Serpukhov accelerator bombarding it with pulses of 32 GeV/s, the statistical sample having reached 4.5 events/ub. Two models which include the interaction kinematics have been used for describing the experimental data, the Lund model of quark fragmentation accounting also for buildup and decay of fundamental resonances as well as the statistical "independent emission of particles" model accounting also for dynamic effects associated with finiteness of the  $p_T$  phase space and for the presence of leading hadrons with the leading effect represented by a Feynman matrix element. Calculations according to the Lund model are based on sampling of all final-state multiplicities from  $5 \cdot 10^5$  events by the standard Monte Carlo method. The thus determined properties of leading  $p$  and  $\bar{p}$  hadrons interacting in diffractionless channels at 32 GeV/s include their velocity distributions, a decrease of their mean longitudinal momenta with increasing multiplicity, the ratios of their longitudinal momenta to that of pions being independent of the final-state multiplicity according to the "independent emission of particles" model and decreasing with increasing final-state multiplicity according to the Lund model. Properties not described by the Lund model are a correlation between absolute values of the two mean transverse momenta, this correlation decreasing with increasing final-state multiplicity, and partial compensation of the transverse proton momentum by the transverse antiproton momentum. The longitudinal momenta of protons and antiprotons at final-state multiplicity of 4-10 are uncorrelated according to the "independent emission of particles" model, and according to experimental data, while the Lund model yields here a correlation. Figures 4; tables 2; references 14: 1 Russian, 13 Western.

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# DETERMINATION OF NUCLEAR VERTEX CONSTANTS (ASYMPTOTIC COEFFICIENTS) FROM CHARGED-PARTICLE TRANSFER REACTIONS

Moscow YADERNAYA FIZIKA in Russian Vol 44, No 5(11), Nov 86 (manuscript received 11 Nov 85) pp 1167-1170

[Article by L. D. Blokhintsev, Scientific Research Institute of Nuclear Physics, Moscow State University, S. M. Rasulev and R. Yarmukhamedov, Institute of Nuclear Physics, UkSSR Academy of Sciences]

[Abstract] A new method of determining nuclear vertex constants is proposed which, unlike the known residue method and method of continuation to a pole, accounts explicitly not only for short-range interaction but also for Coulomb interaction in the case of a charged particle participating in a reaction. The amplitude of a reaction  $A(x,y)B$  is represented as the sum  $M(E,z) = M_1(E,z) + M_2(E,z)$  ( $M_1$  - modified amplitude of polar diagram with singularity nearest to the physical range in the  $z$ -plane, accounting also for Coulomb effects,  $M_2$  - amplitude of background with farther singularities only,  $z = \cos\theta$ ,  $\theta, E$  - scattering angle and kinetic energy of colliding particles in center-of-mass system). The differential cross-section for such a reaction then becomes the sum of three components including an interference component. An analysis of experimental data on reactions  $D(d,n)^3\text{He}$  and  $T(d,n)^4\text{He}$  on this basis has yielded vertices  $G_{\text{dnp}}^2 G_{\text{tdp}}^2$  and  $G_{\text{dnp}}^2 G_{\alpha\text{tp}}^2$  ( $\tau = ^3\text{He}$ ). With quite accurately known  $G_{\text{dnp}}^2 = 0.43 \text{ Fm}$ , it is not possible to calculate  $G_{\text{tdp}}^2$  and  $G_{\alpha\text{tp}}^2$ . In the case of purely short-range interaction, without Coulomb effects, this method needs to be modified and various ways to do it are available. Figures 2; references 12: 4 Russian, 8 Western.

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# RADIATIVE TRANSITIONS ACCOMPANYING ELECTRODISINTEGRATION OF $^7\text{Li}$ NUCLEI INTO TRITON AND $^4\text{He}$ IN GROUND STATE

Moscow YADERNAYA FIZIKA in Russian Vol 44, No 5(11), Nov 86 (manuscript received 24 Sep 85) pp 1153-1157

[Article by Yu. M. Volkov, G. A. Kolomenskiy, Ye. F. Lakovichev, Ye. D. Makhnovskiy, V. V. Popov, V. P. Fominenko, and V. P. Chizhov, Leningrad Institute of Nuclear Physics, USSR Academy of Sciences]

[Abstract] The indirect nuclear reaction  $\gamma + ^7\text{Li} \rightarrow ^7\text{Li}^* \rightarrow \gamma' + ^7\text{Li}^{**} \rightarrow \gamma' + T + ^4\text{He}$  is analyzed, for the purpose of verifying earlier reports about the cross-section for it being comparable with that for the direct nuclear reaction  $\gamma + ^7\text{Li} \rightarrow \gamma' + T + ^4\text{He}$  and about a  $\Delta E_T \approx 150 \text{ keV}$  wide peak at  $E_T = 8.5 \text{ MeV}$



in the energy spectrum of 31 MeV electron bremsstrahlung scattering by  ${}^7\text{Li}$  nuclei. These conclusions have been confirmed by statistically more precise measurements. The experiment was performed with a  $1.5 \text{ mg/cm}^2$  thick  ${}^7\text{Li}$  target and an inner beam of electrons accelerated in the synchrotron at the Leningrad Institute of Nuclear Physics, 4.3-11.2 MeV tritons having been recorded under these conditions. The results, based on a  $\theta = 100^\circ$  wide scattering pattern and calculations involving the Davis-Bethe-Maksimov equation, do not confirm a  ${}^7\text{Li}(\gamma, \gamma' T){}^4\text{He}$  reaction but do indicate possible  ${}^7\text{Li}(\gamma, T){}^4\text{He}$  and  ${}^7\text{Li}(e, T){}^4\text{He}, \gamma'$  reactions yielding 8.5 MeV  $\gamma'$ -quanta along with 6-11.2 MeV tritons within the 11 MeV threshold to 20 MeV excitation range. The authors thank B. S. Ishkhanov, I. M. Piskarev, and others at the Scientific Research Institute of Nuclear Physics (Moscow State University) for discussing the project, and the synchrotron attending personnel at the Leningrad Institute of Nuclear Physics (USSR Academy of Sciences) for assistance. Figures 1; tables 1; references 7: 4 Russian, 3 Western.

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#### PARTIAL NUCLEONIC DECAY CHANNELS FOR DIPOLE GIANT RESONANCE OF ${}^{23}\text{Na}$ NUCLEUS

Moscow YADERNAYA FIZIKA in Russian Vol 44, No 5(11), Nov 86 (manuscript received 26 Nov 85) pp 1145-1152

[Article by A. S. Gavelko, K. M. Igrashev, B. S. Ishkhanov, I. M. Kapitonov, V. I. Mokeyev, and I. M. Piskarev, Scientific Research Institute of Nuclear Physics, Moscow State University]

[Abstract] For an analysis of experimental data on partial photonuclear  $(\gamma, X\gamma')$ -reactions with emission of an X particle and formation of a residual nucleus in a certain  $i$ -th state, a method of determining integral partial cross-sections has been developed which accounts for the difference between thresholds of a reaction under study and the reference reaction and for difference between forms of the respective cross-sections. The method was tested on photodisintegration of the  ${}^{23}\text{Na}$  nucleus. The experiment was performed with a 520 g specimen of metallic Na and a bremsstrahlung beam approximately 10 cm in diameter extracted through a collimator from the betatron at the Moscow State University. The upper energy limit of the radiation spectrum was 32 MeV and  $\gamma$ -quanta removing the excitation from the states of residual nuclei populated during decay of dipole giant resonance in the  ${}^{23}\text{Na}$  nucleus were recorded by means of a coaxial Ge(Li)-detector. The signal-to-noise ratio was boosted by means of filters made of paraffin and Pb, inserted in the collimator channel and suppressing the most intense low-energy background radiation. The integral partial cross-sections were calculated conventionally, by integration from the reaction threshold to the upper limit of the bremsstrahlung spectrum, but taking into account the two systematic errors due to threshold difference and form difference respectively. The partial cross-sections for  $(\gamma, p)$ -reactions and  $(\gamma, n)$ -reactions, specifically  ${}^{24}\text{Mg}(\gamma, p)$  and

$^{32}\text{S}(\gamma, p)$  reactions, or the total cross-section for photoabsorption by the given nucleus were used as the cross-section for the reaction under study and the  $^{16}\text{O}(\gamma, p_3)^{15}\text{N}$  reaction was used as reference reaction. Integral partial cross-sections in 20 decay channels have thus been obtained for dipole giant resonance of the  $^{23}\text{Na}$  nucleus. Also existing data on integral partial cross-sections for  $^{28}\text{Si}(\gamma, p)$ -reactions have been refined by this method. Figures 2; tables 5; references 17: 10 Russian, 7 Western.

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#### NATURE OF TRANSITION TO THERMONUCLEAR FUSION IN TOKAMAK

Moscow FIZIKA PLAZMY in Russian Vol 12, No 12, Dec 86 (manuscript received 22 Oct 85, after correction 27 Jan 86) pp 1444-1450

[Article by A. D. Arinichev, V. Ye. Zhogolev, S. V. Putvinskiy, and V. A. Chuyanov, Institute of Atomic Energy imeni I. V. Kurchatov]

[Abstract] Conditions for transition to thermonuclear fusion in a tokamak, upon adiabatic compression of the hot plasma with attendant inrush of D-T mixture into the evacuated space, are established on the basis of the corresponding transfer equations rather than the standard Lawson criterion not applicable here. Owing to a lack of reliable experimental data on the transfer coefficients, these equations are simplified to one equation of kinetics of the radial temperature profile  $T(r, t)$  in the presence of a temperature-dependent source  $G(T)$ . First high temperatures are considered  $T \gg T_*$ ,  $T_* = 4.4$  keV being the temperature at which the source function becomes  $G(T) = 0$ . Next are considered low temperatures  $T_0 \gtrsim T_*$ , in which case the form of  $G(T)$  is very critical and an analytical solution is difficult. In this case, therefore, the steady-state solution is assumed to separate transient buildup modes and transient decay modes. The trend of the dependence  $\xi_* = r_*/\alpha(\tilde{t})$  ( $r_*$  - radial coordinate at which  $\tilde{T}(r) = 0$ ,  $\alpha(\tilde{t})$  - plasma radius) on  $T_0/T_*$  indicates that a thick initial plasma filament is required for reaching the fusion zone by adiabatic compression with attendant neoclassical losses. Figures 5; references 5: 2 Russian, 3 Western.

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CSO: 1862/70

## MAGNETOHYDRODYNAMIC EQUILIBRIUM AND STABILITY OF FINITE-PRESSURE PLASMA IN ANTILOCK PLASMATRON

Moscow FIZIKA PLAZMY in Russian Vol 12, No 12, Dec 86 (manuscript received 26 Dec 85) pp 1429-1438

[Article by V. V. Drozdov and A. A. Martynov, Institute of Applied Mathematics imeni M. V. Keldysh, USSR Academy of Sciences]

[Abstract] Arrays of open traps for finite-pressure MHD plasma are considered, equilibrium of a shieldless plasma and its stability with respect to small-scale being analyzed for the case of an anisotropic finite pressure and an axisymmetric magnetic field in an antilock plasmatron. Calculations are based on MHD equations with separation of longitudinal and transverse pressure components. Sufficient and necessary conditions for MHD stability are established in the drift approximation, with the Kruskal-Oberman energy principle serving as stability criterion. Limiting plasma pressure profiles calculated on this basis reveal that a finite pressure does not significantly influence the magnetic field distribution and that an increase of the parameter  $\beta = 2p_{\perp m} / B_0^2$  ( $p_{\perp m}$  - maximum transverse pressure,  $B_0$  - minimum magnetic induction in vacuum at the plasma boundary) lowers the stability with respect to small-scale perturbations. A free plasma boundary, far from the containment wall, lowers the stability limit somewhat. Sufficient and necessary conditions for stability in an antilock plasmatron differ appreciably when  $\beta \ll 1$  and converge as  $\beta \rightarrow 1$ . The authors thank V. V. Arsenin and L. M. Degtyarev for formulation of the problem and helpful discussions. Figures 4; references 12: 5 Russian, 7 Western.

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UDC 621.039.61

## EFFECTIVE CHARGE OF PLASMA IN TOKAMAK WITH GRAPHITE WALL AND GRAPHITE DIAPHRAGM

Moscow FIZIKA PLAZMY in Russian Vol 12, No 11, Nov 86 (manuscript received 22 Oct 85, after correction 23 Jan 86) pp 1283-1291

[Article by Yu. D. Pavlov, D. P. Petrov, A. M. Solntsev, A. M. Stefanovskiy, A. L. Terebkov, and A. F. Shcherbak, Institute of Atomic Energy imeni I. V. Kurchatov]

[Abstract] Experiments in the TM-G tokamak facility at the Institute of Atomic Energy were performed for plasma diagnosis, this facility being a modification of the TM-3 facility: graphite wall with 40 cm outside radius, plasma filament 15.6 cm in diameter, diaphragm for pinching the plasma

filament 1 cm high, copper jacket 26 cm in diameter. The graphite wall, mounted in a vacuum chamber, consists of 24 cylindrical segments made of MPG-8 graphite (density  $1.7-1.8 \text{ g/cm}^3$ , electrical conductivity  $10^{-3} \text{ ohm}\cdot\text{m}$ , almost isotropic thermal conductivity, impurity content not more than  $3 \cdot 10^{-5}\%$  Si and not more than  $10^{-5}\%$  B, Mg, Al, Ti, Mn, Fe, Cu each) and beveled at both bases. The parameters of hydrogen plasma in this facility were: current 20-80 kA in a magnetic field of 0.8-3.2 T so that  $q(\alpha) \approx 3$  under all conditions, mean electron concentration  $10^{13}-1.2 \cdot 10^{14} \text{ cm}^{-3}$ , electron temperature at axis of plasma filament 300-1000 eV, ion temperature at central chord 130-260 eV, radiation losses 15-40% of Joule-effect power, discharge duration 14 ms. The radial profiles of the electron temperature were measured, revealing sawtooth oscillations at mean electron concentrations  $2 \cdot 10^{13}-4.2 \cdot 10^{13} \text{ cm}^{-3}$  levels at 20-60 kA current levels correspondingly. Carbon injection into the plasma was measured in an experiment with laser action on the graphite wall, spectral analysis of the plasma showing carbon to be the only impurity besides an almost negligible amount of oxygen ions. This indicates x-radiation consisting of bremsstrahlung emitted by hydrogen, bremsstrahlung and recombinational radiation emitted by carbon ions. The effective plasma charge was calculated by five methods: 1) from the electrical conductivity of the plasma and the profile of the electron temperature ( $I = 40 \text{ kA}$ ), 2) from the bremsstrahlung intensity in the visible region of the spectrum ( $I = 60 \text{ kA}$ ), 3) from the electrical conductivity of the plasma during sawtooth oscillations ( $I = 40 \text{ kA}$ ), 4) from the estimated concentration of highly ionized carbon ions during carbon injection by laser action on the wall ( $I = 40 \text{ kA}$ ), 5) from the percentage excess soft x-radiation ( $I = 60 \text{ kA}$ ). All methods yielded fairly similar results, these results indicating that the effect of carbonization can be reduced by increasing the height of the pinching diaphragm. The authors thank the TM-G engineering staff, their colleagues Ye. I. Dobrokhotoy and M. M. Dremin for collaboration, Yu. N. Dnestrovskiy and V. S. Mukhovatov for discussing specific problems. Figures 8; references 10: 4 Russian, 6 Western.

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## SUPERCONDUCTIVITY

### NUCLEAR MAGNETIC RESONANCE IN HEAVY-FERMION SUPERCONDUCTOR $\text{UBe}_{13}$

Moscow ZHURNAL EKSPERIMENTALNOY I TEORETICHESKOY FIZIKI in Russian Vol 91, No 5(11), Nov 86 (manuscript received 24 Apr 86) pp 1820-1831

[Article by N. Ye. Alekseyevskiy, Institute of Problems in Physics, and Ye. G. Nikolayev, Institute of High-Pressure Physics, USSR Academy of Sciences]

[Abstract] Anomalous properties of the heavy-fermion compound  $\text{UBe}_{13}$  with a cubic structure of the  $\text{NaZn}_{13}$  kind were studied by the method of nuclear magnetic resonance, on  $^9\text{Be}$  nuclei. The structure of this compound consists of U atoms and icosahedral  $\text{Be}_{13}$  clusters with 1 Be-I atom at the center and 12 Be-II atoms at the vertices in each of 8 clusters. The compound becomes a superconductor at a temperature below 4.2 K, its magnetic susceptibility depending on the temperature in accordance with Curie's law in the high-temperature range and ceasing to depend on the temperature below 4.2 K. A polycrystalline specimen was produced by fusion of U and Be in an induction furnace. It was crushed into powder and mixed with paraffin in an agate mortar. Single crystals were grown, also in an induction furnace, by slow cooling of the melt in a BeO crucible. The lattice constant of most specimens was  $10.254 \text{ \AA}$  and their superconducting transition temperature was 0.9 K, but for NMR measurements had been selected a single crystal with a lattice constant  $10.257 \text{ \AA}$  and a superconducting transition temperature 0.55 K. Measurements were made in a stationary autodyne NMR spectrometer with a superconducting magnet, over the 1.8-100 K temperature range in a magnetic field of up to 32 kOe intensity. The magnetic susceptibility was measured by the Faraday method. The polycrystalline specimens was held in a vessel made of beryllium bronze, for measurements under hydrostatic pressure up to 10 kbar. The single crystal was held in a movable fixture for orienting it relative to the magnetic field:  $[100]||H$  or  $[111]||H$ . All the NMR spectra, those at 4.2 K having been obtained at a frequency of 13.1 MHz, were processed on a Hewlett-Packard 1000 computer according to the FILTER program with Fourier transformation after preliminary optimum filtration. The results have yielded isotropic shifts in crystallographically nonequivalent Be positions as well as components of the anisotropic shift tensor and of the electric-field gradient tensor for the low-symmetry position of Be-II with only a mirror symmetry. The principal axes of these two tensors were found to coincide, one of each perpendicular

to the plane of that symmetry and thus also coinciding with the fourth-order axis of the crystal. The isotropic shifting of Be-I and Be-II positions in opposite directions is attributable to spatial oscillations of the spin density about the magnetic moments of U atoms, caused by interaction of conduction electrons and 5f-states in U atoms owing largely to sf-hybridization. The decrease of shifts under higher pressure is evidently related to the attendant decrease of magnetic susceptibility. The authors thank V. I. Nizhankovskiy and Ye. P. Khlybov for assistance in the experiment, Ye. L. Kosarev for assistance in computer processing of the data, and I. Warchulska at the International Laboratory of Strong Magnetic Fields and Low Temperatures (Wroclaw, POLAND) for assistance in magnetic susceptibility measurements. Figures 5; tables 1; references 25: 7 Russian, 18 Western.

2415/12947  
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#### PROPERTIES OF ANISOTROPIC DISORDERED SUPERCONDUCTOR SYSTEM IN NORMAL METAL

Moscow ZHURNAL EKSPERIMENTALNOY I TEORETICHESKOY FIZIKI in Russian Vol 91, No 5(11), Nov 86 (manuscript received 10 Apr 86) pp 1776-1788

[Article by L. G. Aslamazov (deceased), A. A. Dyachkov, and S. V. Lempitskiy, Moscow Institute of Steel and Alloys]

[Abstract] An array of superconducting fibers in a matrix of normal metal is considered, a disordered but unidirectionally oriented and thus strongly anisotropic array having a high lossless current carrying capacity in a strong electric field. First is calculated the critical current density for a system with small volume fraction of the superconducting phase, with a large ratio of distance  $d$  between fibers to coherence length  $\xi_N$  and a correspondingly small superconduction current proportional to  $d/\xi_N$ . Analysis of the relations in this case is based on the theory of streaming, fibers assumed to be thin with a cylindrical geometry. Next are determined the properties of a system with large volume fraction of superconducting fibers, above the critical 0.15 volume fraction and corresponding to formation of infinite clusters. The critical current density in this case is calculated for a single fiber and for a normal matrix of a plane-parallel SNS sandwich, at temperatures above the critical point  $T_c$  and then within the narrow transition range, without a magnetic field and then in a magnetic field. The shunting effect, normal metal shunting the superconducting fibers, in conjunction with the proximity effect, is revealed when the electrical conductivity of the normal metal by far exceeds that of the superconducting phase. The authors thank A. A. Abrikosov, A. I. Larkin, and A. S. Nigmatulin for valuable discussion of the results. References 17: 11 Russian, 6 Western (1 in Russian translation).

2415/12947  
CSO: 1862/79

## LECTURE DEMONSTRATIONS OF PROPERTIES OF SUPERCONDUCTORS AND LIQUID HELIUM

Tomsk FIZIKA in Russian Vol 24, No 7, Jul 86 (manuscript received 29 Feb 85)  
pp 110-112

[Article by Ye. M. Gershenzon, G. N. Goltsman, A. I. Yelantsev, Ye. B. Petrova,  
N. G. Ptitsina and V. S. Filatov, Moscow Pedagogical Institute]

[Abstract] New demonstrations for low temperature physics courses are described. Two transparent Dewar vacuum flasks fitting one inside the other with the external flask for nitrogen (73 cm high) and the internal flask for helium (74 cm high) are used. The helium temperature can be regulated in the 4.2-1.6 K range and the effects of reducing helium to the superfluid state at 2.17 K (lambda point) can be shown: boiling abruptly stops and superfluid flow appears. In order to show the electric and magnetic characteristics of superconductivity, a superconducting NbTi solenoid containing nonsuperconducting wire and germanium and superconducting Nb materials with different critical temperatures is placed in the helium refrigerant vessel. The fall of the resistance at the critical temperatures can be shown. In order to show magnetic field and superconductive current flow properties a shunt of superconductive material is connected in parallel to the coil and is enclosed in a teflon containing with a heater which can vary its temperature. When it is heated and not superconductive, magnetic field effects can be demonstrated and when it is unheated and superconducting a continuous current can be demonstrated. Figures 2; references 4: 2 Russian, 2 Western.

12497/12947  
CSO: 1862/2

## TECHNICAL PHYSICS

### COMPOUND OPTOACOUSTIC GRAVITATIONAL ANTENNA

Moscow ZHURNAL EKSPERIMENTALNOY I TEORETICHESKOY FIZIKI in Russian Vol 91,  
No 5(11), Nov 86 (manuscript received 27 Feb 86) pp 1553-1564

[Article by V. V. Kulagin, A. G. Polnarev, and V. N. Rudenko]

[Abstract] A gravitational antenna with both acoustical and optical degrees of freedom is considered, such an antenna containing a tuned Weber detector of acoustical vibrations and an optical interferometer for recording them. The theory of such an antenna is based on direct interaction of a gravitational wave and an electromagnetic wave during propagation of the latter from one interferometer mirror to the other and back, this interaction resulting in a phase shift of the electromagnetic wave. This effect is analyzed here in the linear approximation with respect to the sensitivity metrics. Calculations are made for a gravitational wave spike of finite duration, containing  $m$  oscillations, and then more specifically for short spikes of duration shorter than  $2L/c$  ( $2L$ -distance between the two interferometer mirrors,  $c$ - speed of light). A long-base compound antenna array of free masses and Weber detectors is considered next, with three possible outputs: one from the long-base interferometer and two from the recording interferometers of Weber detectors. Its design and performance analysis includes the response to excitation of the large interferometer mirror by a gravitational wave and the advantage derived from use of Weber detectors not much less than or equally sensitive as the free masses. The vibrations of a Weber detector can be amplified by means of a displacement transformer appropriately matched. The authors thank V. B. Braginskiy and A. V. Gusev for helpful discussions. Figures 2; tables 1; references 18: 5 Russian, 13 Western (1 in Russian translation).

2415/12947

CSO: 1862/79



# HELIUM BUILDUP IN NICKEL BOMBARDED SIMULTANEOUSLY WITH HELIUM IONS AND HYDROGEN IONS

Moscow POVERKHNOST in Russian No 11, Nov 86 (manuscript received 31 Oct 85)  
pp 119-122

[Article by V. Kh. Alimov, A. Ye. Gorodetskiy, and A. P. Zakharov, Institute of Physical Chemistry, USSR Academy of Sciences, Moscow]

[Abstract] An experimental study was made concerning bombardment of Ni single crystals with  $\text{He}^+$ -ions, alone or also simultaneously with  $\text{H}_2^+$ -ions. The (111) face of a Ni single crystal was bombarded either with 9 keV  $\text{He}^+$ -ions alone or with 9 keV  $\text{He}^+$ -ions simultaneously. In the latter case the two guns were oriented with their axis forming a  $45^\circ$  angle so that the two kinds of ions impinged on the Ni surface from two different directions at equal angles of approximately  $67.5^\circ$ , monoatomic  $\text{H}^+$ -ions having an energy of 4.5 keV. The ratio of  $\text{He}^+$ -ion current to  $\text{H}^+$ -ion current was held constant at 1:20 throughout the dual bombardment. Dual bombardment raised the target temperature to 400 K and the same temperature was maintained by means of a special heater during bombardment with  $\text{He}^+$ -ions alone. The resulting profiles of depthwise He distribution in Ni were determined with the aid of equations describing the kinetics of He implantation in Ni and the kinetics of He reemission from Ni following interaction of radiative defects in Ni with one another and with He atoms. These profiles indicate that the rate of buildup of 9 keV  $\text{He}^+$ -ions in Ni is not influenced by presence of 4.5 keV  $\text{H}^+$ -ions up to a dose of  $1 \cdot 10^{17} \text{ He}^+/\text{cm}^2$ . Further buildup of  $\text{He}^+$ -ions in Ni is impeded by  $\text{H}^+$ -ions, an approximately 3 times higher saturation level being reached by bombardment with  $\text{He}^+$ -ions alone than with  $\text{He}^+$ -ions and  $\text{H}_2^+$ -ions simultaneously. Figures 2; references 7: 3 Russian, 4 Western.

2415/12947  
CSO: 1862/88

UDC 535.37

# ELECTROMAGNETIC SURFACE MODES IN SPECIMENS OF MATERIALS WITH SMALL CHARACTERISTIC DIMENSION

Moscow POVERKHNOST in Russian No 11, Nov 86 (manuscript received 24 Apr 86)  
pp 5-20

[Article by A. Ya. Simonov, Scientific Research Institute of Physical Chemistry imeni L. Ya. Karpov, Moscow]

[Abstract] Development of a systematic methodology for analysis of electromagnetic surface modes in solid media and particularly metal specimens with small characteristic dimension is reviewed, this development having led to

application of the quantum-mechanical theory of perturbations to such fundamental problems as calculation of average photon propagators. The standard "jelly" model is used for describing the electrodynamics of metallic objects with small characteristic dimension in the approximation of random phases, with a gas of conduction electrons in a potential well distorting the uniform field of positive ions regarded as responsible for the electrodynamic properties of the metal. On this basis, using the mathematical apparatus of the complete Hamiltonian, are calculated the frequencies of surface plasma resonances in solid and spherically hollow "classical" metal grains, also in thin metal films and fibers. The role of surface plasma resonances rather than classical electrodynamics is considered in calculation of the cross-sections for interactions of a metal particle and electromagnetic radiation. Such interactions include absorption and elastic scattering of light quanta, inelastic scattering of light quanta and electrons, of particular practical interest being absorption of far-infrared laser radiation, also extinction of surface plasma resonance and scattering of electromagnetic waves electromagnetic surface modes in charged particles. A far-reaching application of this method of analysis is the problem of van-der Waals interaction involving small metal particles and the energy of such an interaction. The author thanks A. A. Lushnikov and V. V. Maksimenko for assistance and helpful discussions. References 92: 16 Russian, 1 Romanian (?) (in Russian translation), 75 Western.

2415/12947  
CSO: 1862/88

UDC 539.1.043

# EFFECT OF COLD $\gamma$ -RADIATION ON MAGNETIC PROPERTIES OF Y-Gd-Fe GARNET

Riga IZVESTIYA AKADEMII NAUK LATVIYSKOY SSR: SERIYA FIZICHESKIKH I TEKHNICHESKIKH NAUK in Russian No 5, Sep-Oct 86 (manuscript received 7 Feb 85) pp 33-37

[Article by M. M. Brezgunov, A. Ye. Petrov, E. S. Plechkens, and U. A. Ulmanis, Institute of Physics, LaSSR Academy of Sciences]

[Abstract] An experimental study of the  $Y_{1.5}Gd_{1.5}Fe_{5}O_{12}$  garnet was made for detection and evaluation of the photomagnetic effect induced by  $\gamma$ -radiation at low temperatures, visible radiation not having been found to induce in it such an effect. Specimens were produced according to the standard ceramic materials technology. The magnetic susceptibility as a function of time over a period of 120 min and its temperature dependence over the 77-300 K range were measured by the compensation method on 1 mm thick and  $4 \times 10$  mm<sup>2</sup> large slices. The parameters of ferromagnetic resonance at 8950 MHz were measured by the standard method on a spherical specimen 3 mm in diameter at 77 K. The saturation magnetization and the coercive force in a field of up to 5 kOe intensity were measured with a vibratory magnetometer over the 77-300 K temperature range. The magnetic susceptibility was found to have a

deep minimum at approximately 120 K and to increase fast with either dropping or rising temperature. A photomagnetic effect, drop of the magnetic susceptibility upon exposure to  $\gamma$ -radiation, was observed only in the temperature range below 120 K. The magnitude of this drop upon exposure to a dose of  $2.2 \cdot 10^5$  R was found to be larger at lower temperature and to increase with increasing exposure rate, which was varied over the 260-3800 R/s range. The magnetic susceptibility was found to decrease in time under  $\gamma$ -radiation, at a rate increasing exponentially with increasing exposure rate up to  $10^3$  R/s and polyexponentially with increasing exposure rate above  $10^3$  R/s. The authors thank Yu. Yu. Krikis for assistance in computer processing of experimental data. Figures 4; tables 1; references 9: 5 Russian, 4 Western.

2415/12947  
CSO: 1862/92

#### PROPAGATION OF SOLITON THROUGH NONLINEAR WAVEGUIDE WITH DISSIPATION AND BOOST PUMPING

Leningrad PISMA V ZHURNAL TEKHNIЧЕСКОY FIZIKI in Russian Vol 12, No 23,  
12 Dec 86 (manuscript received 1 Sep 86) pp 1419-1423

[Article by B. A. Malomed, Institute of Oceanology imeni P. P. Shirshov, USSR Academy of Sciences, Moscow]

[Abstract] Propagation of an optical soliton through a nonlinear waveguide such as a single-mode fiber is considered, boost pumping at points periodically spaced along the path being proposed for compensating the attenuation caused by energy dissipation. The analysis is based on the corresponding nonlinear Schrodinger equation, exactly integrable in the case of zero dissipation. The equation is solved as an inverse problem of scattering, the soliton dynamics being describable by the theory of perturbations and the quiescent-state solution being already known. On this basis are determined the number of light quanta and its spectral density within a soliton alternately attenuating and boosted. Figures 1; references 5: 2 Russian, 3 Western.

2415/12947  
CSO: 1862/83

# METHOD OF SYNCHRONOUS DOUBLE SCANNING FOR ANALYSIS OF NONUNIFORM DISTRIBUTION OF IMPURITY CENTERS

Minsk ZHURNAL PRIKLADNOY SPEKTROSKOPII in Russian Vol 44, No 5, Nov 86  
(manuscript received 23 Apr 85, after completion 6 Jun 86) pp 834-841

[Article by I. Ye. Ivanov and T. M. Naumova]

[Abstract] For analysis of resonant Raman scattering by impurity centers with characteristic nonuniform widening of the 0-0 multiplet and for detection of the latter, there has been proposed synchronous double scanning of the pumping laser and the detection monochromator so that the difference between their frequencies  $\nu_1 - \nu_2$  be equal to one vibrational frequency  $\Omega_s$  of the sought

impurity center and remain constant throughout the scanning. An extension of this method to deviation from resonance is considered, for use where distinct phononless lines do not appear in the fluorescence spectrum and exact determination of a vibrational frequency becomes difficult. The theory is developed on the basis of a fluorescence quantum yield independent of the laser frequency but its intensity being a function of both laser frequency  $\nu_1$  and monochromator frequency  $\nu_2$ , namely equal to the convolution  $\int f(\nu_2 - \omega) g(\nu_1 - \omega) r(\omega) d\omega$  ( $\omega$  - frequency of purely electron 0-0 transition one impurity center,

$r(\omega)$  - nonuniform distribution function referring to impurity centers). Experiments were performed with naphthacene in hexane solution at temperatures of 4.2 K and 77 K, using a coumarin-47 dye laser with a line width  $\Delta_L = 2.5 \text{ cm}^{-1}$

pumped by a  $N_2$ -laser at a pulse repetition rate of 30 Hz and a DFS-24 detection monochromator with a slit of approximately the same spectral width. An important consideration in recording the double-scan spectra is that the frequency difference  $\nu_1 - \nu_2$  and not the respective wavelengths remains constant.

The method was found to be effective with or without distinct phononless lines in the case of selective excitation, with synchronous double scanning in any of the three possible modes: 1)  $\nu_1 - \nu_2 = \Omega_s$ , 2)  $\nu_1 - \nu_2 = \Omega_s + \Delta$  ( $\Delta > \Delta_L$ ),

3)  $\nu_1 - \nu_2 = \Delta$  ( $\Delta_L < \Delta \ll \Omega_s$ . Figures 4; references 6: 5 Russian, 1 Western.

2415/12947

CSO: 1862/80

## TEMPERATURE DEPENDENCE OF UNIFORM RELAXATION COMPONENT IN ABSORPTION SPECTRA OF RHODAMINE-GROUP DYES

Minsk ZHURNAL PRIKLADNOY SPEKTROSKOPII in Russian Vol 44, No 5, Nov 86  
(manuscript received 10 Jun 85) pp 807-812

[Article by V. M. Boytsov and V. I. Yuzhakov]

[Abstract] The absorption spectra of two dyes in ethanol solution, rhodamine 6G and N,N'-bis-pentamethylene-rhodamine, are analyzed for determination of the temperature dependence of their uniform component, considering that a change in the half-width of the uniform component caused by phase relaxation depends largely on the change in temperature while the probability of population relaxation is hardly temperature dependent at all. Structureless absorption bands are describable by the Franck-Condon law and for these liquid solutions of polyatomic molecules, accordingly, the half-width of the uniform Lorentz component is approximated as a quadratic trinomial function of the 0-0 (electron) transition frequency  $\nu_s$  at any temperature  $T = \text{const}$  and a cubic quadri-nomial function of the absolute temperature  $T$  at any frequency  $\nu_s = \text{const}$ .

Calculations on this basis have yielded not only the half-width of that component as a function of the temperature over the 110-300 K range  $\nu_{\text{max}}$  but also the dispersions of nonuniform band I and band II widening as much weaker functions of the absolute temperature over the same range. Figures 5; references 15: 7 Russian, 8 Western.

2415/12947  
CSO: 1862/80

INFRARED FLUORESCENCE OF HYDROGEN FLUORIDE DURING MULTIQUANTUM DISSOCIATION OF  $\text{CF}_3\text{OF}$  MIXED WITH  $\text{H}_2$ 

Minsk ZHURNAL PRIKLADNOY SPEKTROSKOPII in Russian Vol 44, No 5, Nov 86  
(manuscript received 21 Jun 85) pp 785-790

[Article by Ye. B. Aslanidi, N. P. Aslanidi, V. T. Zarubin, R. I. Zaynullin, and Yu. S. Turishchev]

[Abstract] Dissociation of  $\text{CF}_3\text{OF}$  molecules in the presence of  $\text{H}_2$  upon excitation by a pulsed  $\text{CO}_2$ -laser and attendant fluorescence of HF are examined, colorless gaseous  $\text{CF}_3\text{OF}$  being a possible source of  $^{13}\text{C}$  and  $^{18}\text{O}$ . An experiment was performed using a reactor made of stainless steel, with NaCl windows for monitoring the fluorescence within the  $4000\text{--}400\text{ cm}^{-1}$  range of the spectrum.

The composition of the original mixture and the products of the laser-chemical reaction,  $\text{COF}_2$  and  $\text{HF}$ , were monitored with an IKS-29 infrared spectrophotometer and with an MI-1201 mass-spectrometer. The infrared absorption spectrum of the  $\text{CF}_3\text{OF} + \text{H}_2$  mixture contains eight bands, one of them with a peak at  $947.3 \text{ cm}^{-1}$  coinciding with the  $\text{CO}_2$ -laser emission band. The mixture of  $\text{CF}_3\text{OF}:\text{H}_2 = 1:3$  under a pressure of 1.06 kPa was pumped with laser pulses of 12 J energy and 150 ns width at half-amplitude level. Fluorescence was recorded in two mutually perpendicular channels with a set of four infrared light filters and a set of three neutral light filters in each. The results are interpreted in terms of a laser-induced branching chain reaction. The analysis is based on a system of four ordinary linear nonhomogeneous equations of mass balance kinetics for  $\text{CF}_3\text{OF}$ ,  $\text{CF}_3\text{O}^*$ ,  $\text{H}^*$ ,  $\text{HF}^*$  which, solved more easily in the quasi-stationarity approximation, yield the respective concentrations as functions of time and on the basis of measured fluorescence pulse parameters. Calculations have yielded an interaction constant for  $\text{CF}_3\text{OF}$  and atomic hydrogen of the order of  $10^{-12} \text{ cm}^3/\text{s}$ . Figures 3; references 4: 2 Russian, 2 Western.

2415/12947

CSO: 1862/80

#### NONLINEAR RADIATION EMISSION BY FERRITE DURING FERROMAGNETIC RESONANCE

Moscow ZHURNAL EKSPERIMENTALNOY I TEORETICHESKOY FIZIKI in Russian Vol 91, No 3(9), Sep 86 (manuscript received 18 Feb 86) pp 1007-1015

[Article by G. A. Melkov and A. Yu. Taranenko, Kiev State University imeni T. G. Shevchenko]

[Abstract] An experimental study of yttrium-iron-garnet representing a group of ferrites was made, for a determination of its behavior under conditions of strong microwave pumping in the absence of first-order parametric effects but with excitation of spin waves by second-order parametric effects in a constant magnetic field. A spherical single crystal of such a garnet was placed at the antinode of a pumping magnetic field inside a rectangular waveguide, in a constant transverse external magnetic field perpendicular to the wider waveguide walls. The pumping microwave magnetic field in the 3 cm wave band was produced by a 9370 MHz magnetron and entered the waveguide after having passed through a diode, a high-precision attenuator, and a two-directional coupler. After the pumping power threshold for excitation of spin waves had been established, the ratio of actual pumping power to that threshold was determined experimentally from the dependence of the imaginary part of magnetic susceptance at resonance on the intensity of the pumping magnetic field. The results indicate parametric instability of excited second-order spin waves at resonance with the pump and propagating in the direction of the constant magnetic field, thus transversely polarized. Measurements over the 0-1 kW range of pumping power in pulses of 2  $\mu\text{s}$  duration at a repetition rate of 10 Hz reveal nonlinearly varying emission of radiation with the characteristics

of a noise within two frequency bands below the pump frequency, evidently caused by kinetic instability of those spin waves and their decay. Figures 7; references 14: 11 Russian, 3 Western.

2415/12947

CSO: 1862/34

STRONG VIBRATIONAL OVEREXCITATION BEYOND DISSOCIATION LIMIT AND MONOMOLECULAR DECAY OF LARGE  $(CF_3)_3CI$  MOLECULE IN FIELD OF INFRARED LASER

Moscow ZHURNAL EKSPERIMENTALNOY I TEORETICHESKOY FIZIKI in Russian Vol 91, No 3(9), Sep 86 (manuscript received 31 Jan 86) pp 766-778

[Article by V. N. Bagratashvili, S. I. Ionov, M. V. Kuzmin, Scientific Research Center for Technological Lasers, and V. S. Letokhov, Institute of Spectroscopy, USSR Academy of Sciences]

[Abstract] For a study concerning decay of large polyatomic molecules with a  $\geq 30$  vibrational degrees of freedom upon overexcitation by a high-intensity laser, a direct experiment with measurements in real time was performed on  $(CF_3)_3CI$  molecules ( $s=36$ ) in an ionization chamber under a pressure of 0.1 torr and thus sufficiently low to make collisions an insignificant factor. Molecules were excited by infrared radiation from a  $CO_2$  gas laser ( $\lambda = 10.4 \mu m$  wavelength) in pulses of up to 1 J energy and 300 ns duration (100 ns wide at half-amplitude level), after the radiation had passed through a pair of  $CaF_2$  attenuator plates, a NaCl beam-splitter plate, a spherical NaCl lens with  $f=150$  cm focal length, and a cylindrical NaCl lens with  $f=12$  cm focal length. For diagnostics of  $(CF_3)_3CI$ -molecules and I-atoms produced by their decay, a beam of tunable ultraviolet radiation in pulses of up to 100 mJ energy and 8 ns width at half-amplitude level was passed through a focusing quartz lens and then the ionization chamber at a  $60^\circ$  angle to the infrared beam. This probing beam came from a rhodamine C dye laser ( $\lambda = 6080.5 \text{ \AA}$  wavelength) pumped by a XeCl excimer laser, after frequency doubling by a KDP crystal. The second harmonic, with a spectral width of  $1 \text{ cm}^{-1}$ , was tuned to two-photon resonance of three-photon ionization either of I-atoms in the ground state ( $\lambda_1 = 3046.7 \text{ \AA}$  wavelength) or of excited  $I^*$ -atoms ( $\lambda_2 = 3040.5 \text{ \AA}$  wavelength). Measurements were made with two pyroelectric transducers, one picking up ultraviolet radiation and one picking up infrared radiation diverted by the NaCl beam-splitter plate, each feeding signals to a pulse voltmeter, with a pulse voltmeter picking up preamplified and then amplified signals from the ionization chamber, with a frequency meter measuring the time lag between an excitation pulse from the  $CO_2$ -laser and the correspondent probing pulse from the XeCl-laser, and with a colorimeter. The experimental data have been processed to yield the rate of monomolecular decay and the energy distribution of overexcited molecules. The results, compared with predictions based on the

quasi-equilibrium theory of monomolecular decay and with estimates based on the theory of multiphoton excitation, indicate the possibility of strongly over-exciting large iodide molecules by means of infrared multiphoton excitation, using a pulsed  $\text{CO}_2$ -laser, so that all molecules will be above the dissociation limit. One drawback of this method is limitation of the lifetime of over-excited molecules, the lower limit being determined by the duration of laser pulses and the upper limit being determined by the dispersal. The range could be widened, however, with shorter laser pulses achievable by compression techniques and with use of a molecular beam. Another drawback of this method is nonmonoenergetic excitation of molecules above the dissociation limit, but a monoenergetic distribution could be achieved with excitation of high-order harmonics or with inverse electron relaxation during excitation of electron states. The authors thank V. B. Laptev, G. V. Mishakov, Ye. A. Ryabov, V. A. Semchishen, and N. P. Furzikov for assisting in the experiment. Figures 7; references 26: 11 Russian, 15 Western (1 in Russian translation).

2415/12947  
CSO: 1862/34

UDC 539.3

#### CRITERION FOR DYNAMIC FRACTURE OF COLLIDING ELASTOPLASTIC BODIES

Moscow VESTNIK MOSKOVSKOGO UNIVERSITETA, SERIYA 1: MATEMATIKA, MEKHANIKA  
in Russian No 6, Nov-Dec 86 (manuscript received 16 Jul 85) pp 46-51

[Article by A. B. Kiselev]

[Abstract] Collision of two plates is considered and the problem of fracture is treated as one of two-dimensional interaction, with fracture defined according to the Huber-Mises-Hencky toughness criterion. The equations of one-dimensional motion and uniaxial strain for a continuous Prandtl-Rice medium are formulated in a Lagrangian difference grid with Lagrangian coordinates as the independent variables, subject to the three laws of conservation (mass, energy, momentum) formulated in Cartesian coordinates with appropriate initial and boundary conditions at the contact surface. These equations are solved by the numerical method of finite differences according to an explicit scheme, with given design and experimental data on impact of a moving striker plate against a stationary target plate. For illustration, they have been solved for two plates of St3 plain carbon steel: a thin striker plate moving at various velocities against thicker target plates. With the toughness calculated on this basis, the fracture process is analyzed quantitatively as a transient one following collision. The problem can then be extended to and solved for the more general case of three-dimensional interaction of elastoplastic bodies upon collision. Figures 3; references 10: 8 Russian, 2 Western (both in Russian translation).

2415/12947  
CSO: 1862/99



## ACCELERATION OF ATOMS UPON BREMSABSORPTION OF LIGHT

Leningrad PISMA V ZHURNAL TEKHNIЧЕСКОY FIZIKI in Russian Vol 12, No 18,  
26 Sep 86 (manuscript received 15 Jun 86) pp 1123-1125

[Article by M. Ya. Amusya and A. S. Baltenkov, Institute of Engineering  
Physics imeni A. F. Ioffe, USSR Academy of Sciences, Leningrad]

[Abstract] A new mechanism is proposed for explaining the acceleration of atoms in gases and plasmas by incident light; namely, transfer of the photon momentum to atoms, ions, and atomic nuclei during bremsabsorption of light. This mechanism does not require that the frequency of light be equal to the characteristic frequency of atomic excitation, but the efficiency of acceleration is much higher at resonance than otherwise. A quantitative analysis of bremsabsorption, considering that interaction of light is  $M/\bar{z}$  times weaker with an atomic nucleus than with an electron ( $M$ - mass of nucleus,  $\bar{z}$ - charge of nucleus), is based on the cross-section for such an interaction and its comparison with the cross-section for scattering of light, taking into account the dynamic polarizability of an atom. Estimates for protons in atomic hydrogen and argon, assuming a proton temperature of the order of 5 eV and a proton energy of the order of 0.1 eV indicate that the bremsabsorption mechanism is dominant for light in the long-wave region of the spectrum. The results of this analysis may be applicable to acceleration phenomena in the atmosphere of Earth and stars. References 6: all Russian.

2415/12947

CSO: 1862/35

## THEORETICAL PHYSICS

### MEASUREMENT OF NEUTRON LIFETIME BY METHOD OF STORING ULTRACOLD NEUTRONS

Moscow PISMA V ZHURNAL EKSPERIMENTALNOY I TEORETICHESKOY FIZIKI in Russian  
Vol 44, No 10, 25 Nov 86 (manuscript received 18 Oct 86) pp 444-446

[Article by Yu. Yu. Kosvintsev, V. I. Morozov, and G. I. Terekhov]

[Abstract] The neutron lifetime was measured by storing ultracold neutrons in a cylindrical aluminum chamber, 75 cm high and 105 cm in diameter, at a temperature of 80 K under a vacuum of  $10^{-5}$  torr. The equipment included a vacuum pump, a hermetic exhaust valve, a T-form neutron guide, a vacuum jacket, an array of thermal shields, a liquid-nitrogen cooling coil, and a coil for exhaust of gaseous nitrogen. Neutrons were recorded by a proportional  $^3\text{He}$ -detector with shutter in the other arm of the T-guide past the entrance. The frequency of neutron collisions with chamber walls and bottom was regulated by means of a stack of aluminum plates moved up or down by an electromagnet. The inside surface of the chamber was cleaned so as to minimize the loss of neutrons upon impact. The velocity spectrum of ultracold neutrons retained in the chamber was measured by the absorption method and the probability of neutron loss due to collisions with the chamber wall was calculated. The data have been evaluated, taking into account five systematic errors: 1) due to averaging of the geometrical factor as function of initial velocity at the chamber bottom, 2) due to oxidation of aluminum with resulting increase of the cutoff velocity from 3.2 m/s ( $\text{Al}$ ) to 5.2 m/s ( $\text{Al}_2\text{O}_3$ ), 3) due to inaccuracy of velocity distribution measurement, 4) due to leakage of neutrons under the dish shutter above the bottom inlet to the chamber, 5) due to heating and trapping of ultracold neutrons by the residual gas in the chamber. The neutron lifetime of  $903 \pm 13$  s estimated on this basis should be corrected for random errors to  $829 \pm 20$  s. The authors thank O. I. Ivanov for quantitative analysis of impurities in aluminum by the activation method, also V. I. Lushchik, A. V. Strelkov, and Yu. N. Pokotilovskiy for assistance in setting up the apparatus and making the measurements. Figures 3; references 7: 5 Russian, 2 Western.

2415/12947  
CSO: 1862/78

## HIGH-ENERGY NEUTRINOS FROM CYGNUS X-3

Moscow IZVESTIYA AKADEMII NAUK SSSR: SERIYA FIZICHESKAYA in Russian Vol 50, No 11, Nov 86 pp 2245-2248

[Article by J. Wdowczyk and J. Kempa, Institute of Nuclear Research, Lodz University (POLAND)]

[Abstract] A possible flux of high-energy neutrinos from Cygnus X-3 has been calculated on the basis of a model more accurately fitting data on acceleration and data on cosmic rays than the quasi-scaling model, namely with Cygnus X-3 regarded as a twin star consisting of a compact body ( $R = 1.4 \cdot 10^9$  m,  $r = 1.7 \cdot 10^9$  m) and a massive one ( $M = 4 \cdot 10^{30}$  kg). The source of cosmic rays orbiting Cygnus X-3 is assumed to emit a total of  $2 \cdot 10^{40}$  erg/s within a monoenergetic inverse-squared spectrum. With absorption of neutrinos by the star during orbiting of the pulsar around it taken into account in calculation of the energy spectrum of neutrinos reaching Earth, averaging of the neutrino flux over the orbital period of Cygnus X-3 yields an average intensity of the order of  $10^{-7} \text{ m}^{-2} \cdot \text{s}^{-1}$  at the threshold neutrino energy of 100 GeV, such a neutrino flux being recordable by large underground detectors. The authors thank A. Wolfendale for discussion and comments, also A. Ye. Chudakov for information about the Baksansk experiment. Figures 5; references 19: 2 Polish, 17 Western.

2415/12947

CSO: 1862/90

UDC 539.171.017

## MODEL OF QUARK-GLUON STRINGS AND DATA ON COSMIC RAYS

Moscow IZVESTIYA AKADEMII NAUK: SERIYA FIZICHESKAYA in Russian Vol 50, No 11, Nov 86 pp 2087-2089

[Article by A. B. Kaydalov, N. N. Kalmykov, K. A. Ter-Martirosyan, and G. B. Khristiansen, Institute of Theoretical and Experimental Physics]

[Abstract] The model of quark-gluon strings, their formation and annihilation, is used for analysis of hadron interactions. It has so far correctly predicted all characteristics of hadron-nuclear interactions in the energy range below  $10^3$  TeV, namely cross-sections for both total and only elastic interactions, spectra of hadrons generated in these interactions, and deviations from KNO-scaling. It is expected to equally well predict these characteristics of hadron-nuclear interactions in the energy range above  $10^3$  TeV, where the quantum chromodynamic theory does not apply, also to correctly interpret data on wide atmospheric showers and on the composition of primary cosmic rays with energy up to  $10^7$  TeV. Figures 1; references 19: 10 Russian, 9 Western.

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## LOW-ENERGY AND MEDIUM-ENERGY NEUTRINOS IN ATMOSPHERE

Moscow IZVESTIYA AKADEMII NAUK SSSR: SERIYA FIZICHESKAYA in Russian Vol 50,  
No 11, Nov 86 pp 2239-2241

[Article by E. V. Bugayev and V. A. Naumov, Institute of Nuclear Research,  
USSR Academy of Sciences]

[Abstract] The energy spectra of atmospheric neutrinos in the 0.1-10 GeV energy range and the dependence of their vertical intensity on the sharpness of geomagnetic cutoff have been calculated, for the period of minimum solar activity, by methods earlier developed by the authors for calculating the nucleon-nuclear component of medium-energy cosmic rays in the atmosphere. These calculations are based on the one-dimensional model and take into account latest acceleration data on the differential cross-sections for formation of  $\pi^{\pm}$ -mesons and  $K^{\pm}$ -mesons in NA-interactions. For the purpose of a reliability and accuracy check, also the spectra of the muon component at depths of effective neutrino formation have been calculated and the results compared with available experimental data. These energy and intensity spectra, at sea level with zenith angles of  $0^{\circ}$  and  $90^{\circ}$ , reveal a horizontal anisotropy of neutrino fluxes which is minimum for 0.5-0.6 GeV neutrinos and increases appreciably with larger zenith angle at lower energy level. They also indicate that the spectra of electronic neutrinos are more sensitive to the geomagnetic effect than those of muonic neutrinos. Figures 2; references 11: 5 Russian, 6 Western.

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## NEUTRINO ANNIHILATION OF AN ELECTRON-POSITRON PAIR

Tomsk FIZIKA in Russian Vol 24, No 7, Jul 86 (manuscript received 12 Jul 84)  
pp 70-75

[Article by N. V. Samsonenko and Lal Chkhotu Katkhat, Patrice Lumumba  
University]

[Abstract] An analysis is given of the differential cross-section of the process of electron-positron annihilation generating a neutrino and an antineutrino which takes into account spin effects, the interference of charged current and neutral current interactions and also the possibility of nonzero rest mass for the neutrino. The effect of the neutrino rest mass on process characteristics would be small and difficult to observe for high energies but this could be an important factor in energy liberation in stars. The contribution of the rest mass is considerable only in the low energy region and consideration is given to the low velocity nonrelativistic case

for which cross-section formulas are given. The relation of electron and positron velocity to neutrino rest mass is derived. A comparison is made with the Weinberg-Salam model in which the neutrino rest mass is considered zero. The analysis shows that for low energies there are definite effects due to neutrino rest mass for nonpolarized or transverse polarized electrons and positrons for certain spin conditions and neutrino paths. At the present time it would be difficult to demonstrate these effects in the laboratory but they can be assumed to exist on the cosmic scale. References 8: 6 Russian, 2 Western.

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CSO: 1862/2

# FROISSART BUILDUP OF CROSS-SECTIONS, HADRON SPECTRA AND MULTIPLICITIES IN FUTURE ACCELERATORS

Moscow YADERNAYA FIZIKA in Russian Vol 44, No 5(11), Nov 86 (manuscript received 28 Feb 86) pp 1257-1266

[Article by K. A. Ter-Martirosyan, Institute of Theoretical and Experimental Physics, State Committee for Use of Atomic Energy]

[Abstract] Parameters of a supercritical pomeron, which is responsible for Froissart buildup of cross-sections at  $\sqrt{s} \gg m_N^2$  levels, are refined on the basis of experimental ISR and SPS collider data on total cross-sections and on slope of the diffraction cone. Using the Kaydalov-TerMartirosyan model with these more precise values, cross-sections for elastic scattering and slopes as well as hadron spectra and multiplicities are extrapolated into the  $10 \leq \sqrt{s} \leq 100$  TeV energy range in future particle accelerators. Cross-sections are extrapolated along the Froissart curve, inclusive spectra of charged-particle production are calculated according to the quark-gluon model of a pomeron, and the mean multiplicity of charged particles is determined from their multiplicity distribution, with KNO scaling. The author thanks A.D. Yerlykin for pointing out the sensitivity of the pomeron  $\Delta = \alpha_p(0) - 1$  and correlated with  $\eta_p$  to test results. Figures 5; tables 3; references 25: 11 Russian, 14 Western.

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## HADRON COMPONENT OF HIGH-ENERGY COSMIC RAYS AND BUILDUP OF INELASTIC CROSS-SECTIONS

Moscow YADERNAYA FIZIKA in Russian Vol 44, No 5(11), Nov 86 (manuscript received 21 Oct 85) pp 1240-1250

[Article by A. N. Vall, V. A. Naumov, and S. I. Sinegovskiy, Irkutsk State University]

[Abstract] For an interpretation of experimental data on inelastic nucleon-nuclear cross-sections at superhigh energy ( $E \gtrsim 1$  TeV) and on spectra of solitary hadrons in cosmic rays, measurements having been made at AKENO and Fly's Eye facilities, an analytical model of a hadron cascade is used which takes into account logarithmic buildup of inelastic cross-sections with increasing energy at a rate independent of the kind of hadron as well as charge transfer and production of kaons and  $N\bar{N}$ -pairs in  $\pi^+A$ -collisions. Included is the pion-nucleon channel of K-meson production in the atmosphere, but decay of  $\pi^\pm$ -mesons in near vertical directions and  $\pi$  production during  $K^0$  decays as well as N and  $\pi$  production in kaon-nuclear collisions are disregarded. The nuclear components of cosmic rays is treated according to the superposition model. The differential energy spectra of protons and nuclei in primary rays are assumed to be similar and describable by pure power laws, Feynman scaling being applicable to inclusive cross-sections in the fragmentation range and the model of high-energy elastic amplitude being applicable to the buildup of inelastic cross-sections. The results of calculations for the N,  $\pi$ , K component of cosmic rays at shallow depths are in fair agreement with experimental data. The results indicate that  $\pi A \rightarrow NX$  reactions influence inclined but not vertical hadron fluxes in secondary cosmic rays at large depths. The authors thank E. V. Bugayev and I. R. Zhitnitskiy for discussing some aspects of the problem. Figures 7; tables 1; references 28: 18 Russian, 1 Czechoslovak, 9 Western.

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## FOUR-DIMENSIONAL HADRON JETS: UNIVERSAL CHARACTERISTICS OF MULTIPLE PRODUCTION OF PARTICLES

Moscow YADERNAYA FIZIKA in Russian Vol 44, No 5(11), Nov 86 (manuscript received 16 Dec 85) pp 1209-1218

[Article by A. M. Baldin, B. V. Batyunya, I. M. Grameitskiy, V. G. Grishin, L. A. Didenko, A. A. Kuznetsov, and Z. V. Metreveli, Joint Institute of Nuclear Research]

[Abstract] An analysis of hadron jet formation in pp,  $\bar{p}p$ , pC, pTa,  $\pi^-p$ ,  $\pi^-C$  processes, in experiments covering the 6-205 GeV/s range, reveal that the properties of four-dimensional hadron jets are universal. This multiple production of particles has been analyzed by the method of invariants, with processes  $I+II \rightarrow 1+2+3+\dots$  treated in a 4-velocity of 4-momentum space.

Positive invariants  $b_{ik}$  ( $i = I, II$ ;  $k = 1, 2, 3, \dots$ ), squares of distances in such a space, were introduced as principle variables so that a statistical distribution became discernible in cross-sections for those processes. The result is interpreted as deriving from the interaction of a color charge and vacuum irrespectively of other properties of the system, quark or diquark, carrying that charge. Calculation of hadron distributions with respect to  $b_k$  on the basis of quantum chromodynamics would possibly confirm the universality of hadron jet properties, but such a calculation is difficult in the case of large distances. The authors thank the Collaboration on the "Lyudmila" two-meter propane and hydrogen chambers for supplying their experimental data and for helpful discussions, also the CERN - Prague, Amsterdam - Helsinki - Liverpool - Stockholm, and Argonne - Montreal - Toronto Collaborations for supplying data  $\bar{p}p$ -interactions at 5.7 GeV/s and 12 GeV/s and on  $pp$ -interactions at 205 GeV/s. Figures 6; references 22: 9 Russian, 13 Western.

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## EFFECT OF NOISE ON FORMATION OF OPTICAL SOLITONS IN LIGHTGUIDES

Moscow KVANTOVAYA ELEKTRONIKA in Russian Vol 13, No 11, Nov 86 (manuscript received 27 Aug 85) pp 2243-2248

[Article by A. I. Maymistov, E. A. Manykin, and Yu. M. Sklyarov, Moscow Institute of Engineering Physics]

[Abstract] Propagation and kinetics of a light pulse with noise in the form of random initial amplitude or phase modulation in a nonlinear waveguide are analyzed on the basis of the standard nonlinear Schrodinger equation in dimensionless form and its solution by numerical means using the implicit Crank-Nicolson scheme. Both symmetric and asymmetric solitons are considered, conditions for filtration of each being established with complete "purification" attainable eventually. The results indicate no qualitative difference between the effect of amplitude modulation and the effect of phase modulation, the principal effect being fluctuation of the soliton velocity and phase shift without significant fluctuation of its amplitude and duration. There still remains the problem of critical r.m.s. noise amplitude preventing a  $P=1$  probability of soliton formation and possibly stimulating formation of random pulses. Figures 4; references 20: 7 Russian, 13 Western.

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## CONTAINMENT OF ALPHA PARTICLES IN COMPACT TORUS

Moscow FIZIKA PLAZMY in Russian Vol 12, No 11, Nov 86 (manuscript received 5 Apr 85, after correction 8 Jul 85) pp 1292-1297

[Article by S. V. Bozhokin, Leningrad Polytechnic Institute imeni M. I. Kalinin]

[Abstract] Magnetic confinement of  $\alpha$ -particles in a compact torus or a Field Reversed Configuration is examined, with absolute confinement considered in determination of critical surfaces from which an  $\alpha$ -particle will start moving without subsequently ever crossing the torus separatrix. Analysis is based on two mathematical models, Hill model and Maschke-Henneger model, assuming an axisymmetric magnetic field with only two components  $B(\rho, \phi, z) = B_\rho, 0, B_z$  in the torus. The condition for the classically attainable trajectory to lie entirely within the compact torus is established according to each model. Each model yields a different equation for the critical curve. Comparative calculations for 3.52 MeV  $\alpha$ -particles produced in a D-T reaction in a 50 kG magnetic field indicate that the critical curves according to the two models begin to differ appreciably when the ratio  $r_\alpha/r_s$  ( $r_\alpha$  - Larmor



radius of  $\alpha$ -particle,  $r_s$  - radius of torus separatrix) becomes smaller than 1/40. The author thanks E. A. Choban for helpful discussion. Figures 3; references 18: 5 Russian, 13 Western.

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#### NEUTRINO ELECTRODYNAMICS AND POSSIBLE PHENOMENA INVOLVING SOLAR NEUTRINOS

Moscow ZHURNAL EKSPERIMENTALNOY I TEORETICHESKOY FIZIKI in Russian Vol 91, No 3(9), Sep 86 (manuscript received 25 Apr 86) pp 754-765

[Article by M. B. Voloshin, M. I. Vysotskiy, and L. B. Okun, Institute of Theoretical and Experimental Physics]

[Abstract] The electromagnetic moment matrix is constructed for a neutrino according to the standard  $SU(2)_L \times U(1)$  theory, this  $\mu$ -matrix being proportional to the mass  $m$ -matrix when the right neutrino is an  $SU(2)$  singlet and the moment being increased in the presence of right current as in the case of left-right symmetry. The magnitude elements in the moment matrix is estimated, some found to be of the order of  $10^{-10}$  Bohr magneton, astrophysical measurements and nuclear reactor experiments having established some upper bounds. Motion of a neutrino including its oscillations is analyzed, first for a neutrino in vacuum and then for a neutrino propagating through matter such as that of the sun. In the absence of an electromagnetic field there occur no inversions of solenoidality, in a transverse magnetic field there occur flavor oscillations and spin precession dependent on the magnitude of the difference between left neutrinos' and right neutrinos' interaction matrices relative to the product of magnetic field intensity and magnetic moment. The results of this analysis bear on possible phenomena involving solar neutrinos such as seasonal and 11-year variations of neutrino fluxes respectively correlating and anticorrelating with solar activity cycles. Neutrinos falling into the convection zone should have a sufficiently large magnetic moment, their interaction with matter in the convection zone should not appreciably suppress their spin precession, and they should not be depolarized by a constant magnetic field in the interior of the sun, also the Mikheyev-Smirnov mechanism should be operative. Verification of these conjectures will require better than existing instruments for neutrino detection and magnetic moment measurement to be available by the end of this decade, solar activity being expected to peak again during or about the year 1990. Such an instrument, the ICARUS detector, using liquid argon and sensitive to e-scattering of neutrinos with energy higher than 5 MeV is being developed by the CERN-Harvard-Milano-Roma-Tokyo-Wisconsin Collaboration. The authors thank B. Gavel for pointing out the possibility of large electromagnetic moments in supersymmetric systems containing heavy fermions, A. A. Ruzmaykin and P. V. Sasorov for discussing the structure of the sun's magnetic field, S. I. Blinnikov, A. A. Ruzmaykin, A. V. Tutukov, and L. R. Yungelson for discussing the depth-wise profiles of density and isotopic content distribution in the sun, also

Z. G. Berezhiani, Ye. A. Gavryuseva, A. D. Dolgov, B. L. Ioffe, A. V. Fedotov, and M. Yu. Khlopov for other helpful discussions. Figures 4; references 29: 11 Russian, 18 Western.

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# CALCULATION OF THE DENSITY OF STATES IN DISORDERED QUANTUM SYSTEM OF PARTICLES BY MONTE CARLO METHOD

Moscow TEPILOFIZIKA VYSOKIKH TEMPERATUR in Russian Vol 24, No 6, Nov-Dec 86  
(manuscript received 16 Oct 85) pp 1041-1048

[Article by V. S. Filinov, Institute of High Temperatures, USSR Academy of Sciences]

[Abstract] For the purpose of theoretically analyzing disordered quantum systems of particles such as a nonideal high-pressure plasma with significant particle interaction, a Monte Carlo method has been developed which does not hinge on use of a small parameter. The method is based on calculating the local density of states of a particle as a function of eigenvalues and eigenfunctions in the Hamiltonian, this density being equal to twice the imaginary part of the Green function in the corresponding steady-state Schrodinger equation. Evaluation of this Green function involves an inverse Laplace transformation of a continuous Feynman integral or rather its finite-dimensional approximation. Finite-dimensional approximation by the proposed Monte Carlo method, with the Feynman integral represented as the mathematical expectation of a function of a random variable with a certain probability density distribution, is shown to be more accurate than finite-dimensional approximation along trajectories. This is demonstrated on calculation of the density of states as a probabilistic quantity for a free particle in a field with a "solitary" potential well and in a field with a periodic potential. The results indicate that the method is quite accurate even with only a rough approximation of continuous integrals. Evaluation of each tabulated Green function for the system on a BESM-6 high-speed computer requires 5-20 minutes. The author thanks A. N. Lagarkov, A. G. Grivtsov, and Yu. Ye. Lozovik for discussion and valuable comments. Figures 3; tables 4; references 14: 6 Russian, 8 Western (3 in Russian translation).

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